APR 1 2 1926

Engineering Library

The Engineer.

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VOL. CXLI.—No. 3666] LONDON: FRIDAY EVENING, APRIL 2, 1926 [PRICE ONE SHILLING BY INLAND POST 1s. 3d.

PUBLIC NOTICES

G.I.P. RLY. ELECTRIFICATION.

The Director-General, India Store Department, Branch No. 15, Belvedere-road, Lambeth, S.E. 1, invites TENDERS for about EIGHT MILES of :—

22,000-VOLT CABLES.

Tenders due Friday, 30th April, 1926, before 2 p.m. Specifications and form of Tender obtainable from the above address at a fee of 10s. each, which will not be returned. 2026

The Director-General, India Store Department, Branch No. 15, Belvedere-road, Lambeth, S.E. 1, invites TENDERS for :—

1. METALLIC FITTINGS for RAILWAY CARRIAGES.
2. STEEL BRIDGE WORK.

Tenders due on the 20th April, 1926, for No. 1, and on the 26th April, 1926, for No. 2.

Tender forms obtainable from above. 2027

Heavy Gap Lathe, Screw cutting, Self-acting, Surfacing and Sliding, 18in. centres, 12ft. bed. Complete with Change Wheels, Driver Plate, 2 Face-plates, 2 Bell Chucks, Countershaft with Fast and Loose Pulleys with Striking Gear, with 2 J Hangers for fixing, also various Plates, bolts, &c.—Can be inspected at H.M. PRISON, Wakefield. 2028

Civil Engineer Required by the GOVERNMENT of TANGANYIKA TERRITORY for the PUBLIC WORKS DEPARTMENT for a tour of 20 to 30 months' service, with possible extension. Salary £700 a year, rising to £800 a year by annual increments of £25. Free passages and liberal leave on full salary. Candidates, 30 to 35 years of age, should be Associate Members of the Institution of Civil Engineers and have had experience in the reconnaissance, location and survey of roads in other Colonies. Should be capable of designing and preparing bridge plans, estimates, &c., and supervising construction.—Apply at once by letter, stating age, qualifications and particulars of experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W. 1, quoting M/14395. 2020

The Government of India REQUIRE an INSPECTOR OF ENGINEERING STORES for service in the Indian Stores Department. Candidates must possess good general education up to the Institution of Civil Engineers' standard and drawing-office experience, and have served a regular apprenticeship in engineering workshops. It is essential that they should have specialised in tructural steel and bridge work. Age preferably between 25 and 35 years.

Agreement for five years in the first instance. Pay at the rate of Rs. 500, rising by annual increments of Rs. 50 to Rs. 750 per calendar month, with certain allowances. Commencing pay within the limits stated will be fixed with reference to age and qualifications. Free first-class passage to India. Provident Fund.

Further particulars and forms of application should be obtained from the SECRETARY to the HIGH COMMISSIONER FOR INDIA, 42, Grosvenor-gardens, S.W. 1. Last date for receipt of applications 11th April, 1926. 2040

WORKS MANAGER.

Wanted for Admiralty ESTABLISHMENT on the Clyde, competent MECHANICAL ENGINEER for POST of WORKS MANAGER on a non-pensionable basis.

Applicants must have good practical and theoretical knowledge of engineering and experience in connection with high-grade work of great accuracy, including Jigs, Tools, and Gauge Making. A first-hand knowledge of modern cost accounting would be an advantage. Preference will be given to ex-Service men.

Application forms are not required. Reply in writing, in first instance, enclosing copies of recent testimonials and full particulars of qualifications, experience, age, &c., to SECRETARY (C.E. Branch), Admiralty, London, S.W. 1, by 17th April, 1926.

Scale of salary £500-£20-£650 per annum, plus Civil Service bonus, which is liable to variation every six months according to the cost of living. Entry would be at the minimum of the scale, which, with current bonus, amounts to £696 per annum. 2045

University of Liverpool.

FACULTY OF ENGINEERING.

DEAN: Professor C. O. BANNISTER, M.Eng., Assoc. R.S.M., F.I.C., M. Inst. M.M.

Prospectus and full particulars may be obtained on application to the Registrar of Courses designed for Students desiring to qualify as Mechanical, Electrical, Civil or Marine Engineers, as Naval Architects or as Metallurgists and Metallurgical Engineers. 2044

Metropolitan Borough of GREENWICH.

CONSTRUCTION OF JETTY.

The Council of the Metropolitan Borough of Greenwich is prepared to receive TENDERS for the CONSTRUCTION of a REINFORCED CONCRETE JETTY at its Tunnel-avenue Depot, East Greenwich.

Copies of the drawings and specification, together with the form of Tender, may be obtained upon application to the Borough Engineer and Surveyor, Town Hall, Greenwich, S.E. 10, between the hours of 10 and 4 p.m. (Saturdays, 10 and 12 Noon), and upon payment of a deposit of £5 5s., which will not be refunded except upon receipt of a bona fide Tender which is not subsequently withdrawn.

The specification does not provide for any particular system of reinforcement, but contractors must submit with their Tenders detail drawings and particulars of the system they propose to employ.

Contractors will be required to pay such rates of wages and observe such hours and conditions of labour as are recognised by Associations of Employers and Trade Unions, or settled by Arbitration Court legally established.

Sealed Tenders, endorsed "Tender for Jetty," must be delivered to the undersigned not later than Twelve o'clock Noon on Monday, the 10th May, 1926.

The Council does not bind itself to accept the lowest or any Tender.

FREDERICK J. SIMPSON, Town Clerk.

Town Hall, Greenwich, S.E. 10,
29th March, 1926. 2054

The Engineer

PRINCIPAL CONTENTS OF THIS ISSUE.
ARRANGED FOR CARD INDEXING.

Midi Railway of France Hydro-Electric Developments.
THE ENGINEER, 2 - 4 - 26.

Institution of Naval Architects—No. II.
THE ENGINEER, 2 - 4 - 26.

The Report on the Coal Industry.
(H. E. ARMSTRONG.) THE ENGINEER, 2 - 4 - 26.

The High Efficiency Oil Engine—No. II.
(CHORLTON, INST. MECH.E.) THE ENGINEER, 2 - 4 - 26.

Traditional Architectural Forms.
(WILLIAM HARVEY.) THE ENGINEER, 2 - 4 - 26.

Temperature Variation and Heat Stresses in Diesel Engines.
(R. SULZER.) THE ENGINEER, 2 - 4 - 26

Double-Acting Marine Oil Engine—No. II.
THE ENGINEER, 2 - 4 - 26.

Industry and Trade.
THE ENGINEER, 2 - 4 - 26

A New Form of Reinforced Concrete Retaining Walls.
THE ENGINEER, 2 - 4 - 26.

PUBLIC NOTICES

The Manchester Steam Users' ASSOCIATION.

The ANNUAL GENERAL MEETING of the MEMBERS was held in the Board Room of the Association, at their Offices, 9, Mount-street, Manchester, on Tuesday, March 23rd, Harold Lee, Esq., J.P. (Manchester), President in the chair, when the following resolutions were adopted :—

Moved by the Chairman, seconded by J. T. Browne Esq., Pendlebury (Vice-President), and resolved :—

"That the Report of the Committee of Management to the Subscribers, together with the Financial Statement, for the year 1925, be and is hereby approved and adopted."

Moved by Edward Turnbull, Esq. (Messrs. Tate and Lyle, Ltd., Liverpool), seconded by W. H. Hall, Esq. (Messrs. Robert Hall and Sons, Ltd., Bury), and resolved :—

"That the thanks of the Association are due and are hereby presented to the Committee of Management for their past services, and that the following gentlemen be elected the Committee for the ensuing year, with power to add to their number :

COMMITTEE OF MANAGEMENT.

HAROLD LEE, Esq., J.P., Manchester.
A. NORMAN DUGDALE, Esq., J.P., Blackburn.
JAS. STANLEY ADDISON, Esq., London.
J. T. BROWNE, Esq., Pendlebury.
ALFRED H. J. COCHRANE, Esq., Openshaw.
CHARLES W. CROSSLEY, Esq., J.P., Halifax.
GEORGE LENNARD BOLDEN, Esq., Manchester."

Moved by F. W. Oldham, Esq. (Accrington Cotton Spinning Co., Ltd., Accrington), seconded by —. Hanson, Junr., Esq. (Messrs. Frederick Smith and Co., Ltd., Salford), and resolved :—

"That Messrs. F. W. Popplewell and Son, Chartered Accountants, Manchester, be appointed Auditors of the Association's Accounts for the year 1926."

JAMES PARR, Secretary.

9, Mount-street, Albert-square, Manchester,
24th March 1926. 2036

Borough of Ryde.

SUPPLY OF TURNSTILES.

The above Council invite TENDERS for the SUPPLY and DELIVERY of FOUR MOVABLE REGISTERING TURNSTILES.

Sealed Tenders, which should be endorsed "Turnstiles," should reach my office not later than Noon on April 21st, 1926.

The Council do not bind themselves to accept the lowest or any Tender.

B. F. HOLNESS, M. Inst. M. and Cy. E.,
Borough Engineer and Surveyor.

Town Hall, Ryde, I.W.,
24th March, 1926. 2039

PUBLIC NOTICES

Karachi Port Trust.

The Board of Trustees of the Karachi Port Trust are prepared to receive through their Consulting Engineers and Agents TENDERS for :—

(A) 6000 TONS PORTLAND CEMENT in Casks.
(B) 2750 TONS PORTLAND CEMENT in Casks.

Specification and form of Tender can be obtained at the offices of Messrs. RENDEL, PALMER and TRITTON, 12-14, Dartmouth-street, Westminster, S.W. 1, to whom Tenders must be submitted not later than 10 a.m. on the 3rd May, 1926.

A fee of 20s., which is not returnable, will be charged for the specification. 2053

County Council of Surrey.

APPLICATIONS are INVITED for the undermentioned APPOINTMENTS in the Highways and Bridges Department :—

(1) SURVEYING ASSISTANT. Commencing salary £300 per annum, rising by annual instalments of £15 to £450 per annum.
(2) SURVEYING ASSISTANT. Commencing salary £190 per annum, rising by annual instalments of £10 to £290 per annum.

Applicants should be experienced in the making of surveys, sections and plans, and should hold the Testamur of the Institution of Municipal and County Engineers or be Associate Members of the Institution of Civil Engineers or the Surveyors' Institution.

The appointments will be subject to the provisions of the Local Government Officers Superannuation Act, 1922. Applications on the prescribed forms should reach the undersigned not later than 9th April, 1926.

Canvassing is prohibited and will be deemed a disqualification.

T. W. WEEDING, Clerk of the Council.

The County Hall,
Kingston-on-Thames,
25th March, 1926. 2038

Sudan Government Railways REQUIRE the SERVICES of a DISTRICT LOCOMOTIVE SUPERINTENDENT. Age 26 to 32, preferably single. Candidates should have been trained on a British Railway or in a Locomotive Builders' Works, and should have good knowledge of the working of a locomotive department. A.M.I.C.E. degree or equivalent desirable. Commencing salary £480 to £540 per annum, according to age and qualifications (£1 equals £1 0s. 6d.). Progressive and pensionable post if satisfactory. Strict medical examination. Free first-class passage. Liberal leave with assisted passages.—Apply by letter to ADVISORY ENGINEER, Sudan Government London Office, Wellington House, Buckingham-gate, S.W. 1, marking envelope "Dist. Loco. Supt." 2052

PUBLIC NOTICES

County Borough of Grimsby.

APPOINTMENT OF CLEANSING SUPERINTENDENT.

The Cleansing Committee of the Corporation invite APPLICATIONS for the POSITION of CLEANSING SUPERINTENDENT. The person appointed will have charge of the Household, Scavenging, Street Cleansing, Destructor, Pulverisers, Horses, Motors, &c. Salary £350 per annum (paid monthly). None but thoroughly competent and experienced men should apply.

Further particulars and a form of application can be obtained from the undersigned. Canvassing, either directly or indirectly, will be a disqualification.

Applications, on the prescribed forms, accompanied by copies only of three recent testimonials, addressed to the Chairman of the Cleansing Committee and endorsed "Cleansing Superintendent," should be delivered at my office not later than Noon on Monday, 19th April, 1926.

JOHN W. JACKSON, Town Clerk.

Municipal Buildings,
170, Victoria-street,
April, 1926. 2061

New Zealand Government Railways.

APPLICATIONS are INVITED for the POSITION of ASSISTANT CHIEF MECHANICAL ENGINEER. Salary £850 per annum rising to £1000. Age limit 45. Applicants must be Associate Members or Members of the Institution of Mechanical Engineers.—Full particulars and forms of application obtainable from the HIGH COMMISSIONER FOR NEW ZEALAND, 415, Strand, London, W.C. 2, by whom completed applications will be received up to and including the 30th April, 1926. 1902

New Zealand Government Railways.

APPLICATIONS are INVITED for the POSITION of CHIEF DRAUGHTSMAN, Locomotive Branch. Salary £715 per annum. Age limit 45. Applicants must be Associate Members of the Institution of Mechanical Engineers or have passed equivalent examination.—Full particulars and forms of application obtainable from the HIGH COMMISSIONER FOR NEW ZEALAND 415, Strand, London, W.C. 2, by whom completed applications will be received up to and including the 15th April, 1926. 1901

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

WANTED for Large Works, a First-class SUPERINTENDENT STOREKEEPER. Must possess a thorough knowledge of the most up-to-date Storekeeping Methods and have held a similar post in large modern works with success.—Address, stating full experience, age, salary expected, present and past positions, in confidence, 1978, The Engineer Office. 1978 A

WANTED, LIMIT GAUGE and PRECISION TOOL EXPERT of first-class experience, capable of reorganising and standardising limit gauge system between drawing-office and works in large motor vehicle manufacturing establishment. Must have carried out similar work previously. State age, experience, and salary required.—Address, 2063, The Engineer Office. 2063 A

WANTED, MACHINE SHOP MANAGER, with first-class experience in production work, including Gear Cutting, Jigs and Tools, &c. State age, experience, and salary required.—Address, 2051, The Engineer Office. 2051 A

CONSULTING ENGINEER and MANUFACTURER has an OPENING in his London Office for a PREMIUM PUPIL. Must have a good general education, some knowledge of drawing an advantage. Would be given a thorough training with a view to a permanent post when proficient. Interview by appointment.—Address, 1986, The Engineer Office. 1986 A

ENGINEER WANTED; Must be Theoretical and practical, for manufacturing Automatic Weighing Machinery as used for material handling plants; also to Take Charge of Small Works. State experience age, and salary required.—Address, P1754, The Engineer Office. P1754 A

OVERSEAS REPRESENTATIVE.—Good OPENING AVAILABLE in connection with Abdulla Cigarettes for the right man with successful experience in developing business for branded British commodities overseas.—Write, with full particulars, to ABDULLA and CO., Ltd., 178, New Bond-street, London, W. 1, marking envelope "Overseas." 2021 A

PART-TIME ASSISTANCE of a Gentleman with scientific qualifications and commercial experience REQUIRED. Connections or experience with editors and publishers and literary tasks an advantage.—Address, 2041, The Engineer Office. 2041 A

SITUATIONS OPEN (continued) Page 2.

SITUATIONS WANTED, Page 2.
AGENCIES, Page 2.
MACHINERY, &c., WANTED, Page 96
PARTNERSHIPS, Page 2.
AUCTIONS, Page 96.
FOR SALE, Pages 2, 3 and 96.
BUSINESSES and PREMISES (For Sale, etc.), Page 96.
PATENTS, Page 2.
WORK WANTED, Page 3.

For Advertisement Rates see Page 387, Col. 1.

INDEX TO ADVERTISEMENTS Page 95.

SITUATIONS OPEN (continued)

TECHNICAL PUBLICITY, ADVERTISING AND CATALOGUE WORK.—WANTED, for Engineering Firm, first-class MAN with initiative and ideas. Take full charge.—Address, "PUBLICITY," Wm. Porteous and Co., Advertising Agents, Glasgow. P1759 A

WANTED, LADY TRACER, London; must be quick, neat and accurate.—Address, 2029, The Engineer Office. 2029 A

WANTED, TWO First-class Steel Railway Car DRAUGHTSMEN, with a thorough knowledge of latest Steel Car practice. State salary required.—Address, 2065, The Engineer Office. 2065 A

DRAUGHTSMAN REQUIRED, Experienced in the design of Road Rollers, Steam and Internal Combustion. State age, experience, and salary required.—Address, P1753, The Engineer Office. P1753 A

DRAUGHTSMAN WANTED, Constructional Engineers (Buildings), able to do job without supervision; Yorkshire. State experience and wages required.—Address, 2049, The Engineer Office. 2049 A

EXPERIENCED DRAUGHTSMAN REQUIRED for temporary position, accustomed to the designing of Girder work and other Constructional Work. Calculations of Stresses, &c.—Apply by letter to A. NEWLANDS, Divisional Engineer's Office, L.M. and S. Railway, Crewe, stating age, experience, and salary required. 2044 A

FIRST-CLASS CARRIAGE and WAGON DRAUGHTSMEN.—Apply, stating age, salary required, and full particulars of experience, to the MIDLAND RAILWAY-CARRIAGE and WAGON CO., Ltd., Washwood Heath, Birmingham. 2062 A

MECHANICS, FITTERS and ENGINEERS, Desiring more congenial and lucrative employment, should write for particulars of my intensive course in draughtsmanship. There is an increasing demand for qualified draughtsmen and you can learn this interesting profession while you are earning. Postal or private tuition by arrangement.—PERCY PITMAN, M.I. Mech. E., 25 Victoria-street, Westminster, S.W.1. 1907 A

PATTERNMAKERS.—Permanency for Capable Men. District rate.—Apply, P. J. SMITH, 2A, Wynyatt-street, Goswell-road, E.C. 1. 1927 A

SITUATIONS WANTED

A.M.I.M.E., Expert DESIGNER. Inventors' and others' Ideas Developed. B.P. and Tracings Supplied. Estimates given. References.—Address, P1755, The Engineer Office. P1755 B

ENGR. (30). Extensive Experience Heavy Marine oil engines. 1st Class B.O.T. Certificate, steam and motor, excellent refs., DESIRES POSITION with Consulting or Supt. Engineers.—Address, P1757, The Engineer Office. P1757 B

ENGINEER (50) SEEKS CHANGE, Any Suitable position. Moderate salary; 16 years manager foundry and engineering works, 10 estimating and drawing-office, 9 shops, &c.—Address, P1752, The Engineer Office. P1752 B

EXTRA-FIRST CLASS (B.O.T.) ENGINEER, Age 27, OPEN for POSITION at home or abroad, with prospects depending on work and ability.—Address, P1751, The Engineer Office. P1751 B

POST WANTED with General Engineers, London Dist., by Chief Draughtsman; energetic progressive organiser, capable controller, competent engineer, with wide mech. experience, sound training.—Write, G., 48, Queen's-road, New Malden. P1756 B

REINFORCED CONCRETE.—ENGINEER (26), experienced in design and construction of reinforced concrete, London and Midlands, DESIRES POSITION in or near London. Would accept spare-time work. Ex. refs.—Address, 2064, The Engineer Office. 2064 B

REQUIRED by Young Engineer with Good Knowledge of oil engines and general engineering, APPOINTMENT in India or the East, age 23, with experience in commercial and selling side as well as the manufacture, installing, testing, and erection, to Box E. 4177, c/o Dawson's, 118, Cannon-street, E.C. 4. 2030 B

WORKS MANAGER SEEKS APPOINTMENT. Mechanical, Dairy, Brewery and Confectionery Trades; 25 years' exp., 10 years as above. Administrative and productive ability, initiative; sound references.—Address, P1950, The Engineer Office. P1950 B

MACHINE SHOP FOREMAN: Accurate General machining, rapid production, gear cutting, good organiser, keen and capable.—Address, P1758, The Engineer Office. P1758 B

AGENCIES

WANTED, AGENCIES for India by Large Engineering Firm having over half a century's connections in that country, for Machine Tools, Workshop Appliances, Cranes, Valves, Power Plant Specialities, &c. Side lines will be considered.—Address, 1939, The Engineer Office. 1939 D

WANTED by Old-established Firm in South Wales, who has good connection with collieries, works, and railways, ONE or TWO First-class AGENCIES.—Address in first instance, P1708, The Engineer Office. P1708 D

PARTNERSHIPS

IF YOU ARE SEEKING
A PARTNER or PARTNERSHIP
or wish to buy or sell a
BUSINESS or WORKS
Write:
WHEATLEY KIRK, PRICE & CO.,
46, Watling Street,
London, E.C. 4.
Established over 70 years.

PARTNERSHIPS and ACTIVE DIRECTORSHIPS WANTED in Mechanical, Constructional, Electrical Engineers, &c., for Clients with technical experience and capital from £1000 to £20,000.—GILBERT and PRATT, 18, Walbrook, London, E.C 4. Ex. C

EDUCATIONAL

COACHING in CIVIL ENGINEERING SUBJECTS. —To G. W. M. BOYCOTT, Assoc. M. Inst. C.E., Chandos House, Palmer-street Westminster, S.W. 1. 1881 E

CORRESPONDENCE COURSES for Inst. C.E., Inst. Mech. E., London Univ. (Matric, Inter B.Sc.), and ALL ENGINEERING EXAMINATIONS, personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Eng., London, Assoc. M. Inst. C.E., Chartered Civil Engineer, M.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams., comprising hundreds of successes. Courses may commence at any time.—Apply to Mr. TREVOR W. PHILLIPS, B.Sc. (Hons.), A.M.I.C.E., &c., 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN-STREET, LIVERPOOL. Telephone No. 1118 Bank. Ex. E

LEARN SURVEYING and LEVELLING.—Thorough practical instruction by expert.—E. MOUL (late L.S.W. and S.P.D. Ry.), Hollybank, Woking. P1749 E

PITMAN'S POSTAL COURSE IN ENGINEERING DRAWING.—My old-established and intensive course in Mechanical Draughting and Machine Design is of the greatest value to all those preparing for examinations, or who are employed in the daytime and are anxious to obtain a more interesting and profitable occupation. Students prepared for all Engineering examinations. The course may be started at any time.
Send for particulars and enrolment form.
PITMAN'S, 25, Victoria-street, London, S.W. 1.

PATENTS

KING'S PATENT AGENCY, Ltd. (Director, B. T. KING, C.I.M.E., Registered Patent Agent, G.B., U.S., and Canada). Inventions advice handbook and consultations free.—146A, Queen Victoria-street, London, E.C. 4. 40 years' refs. 'Phone: Central 682. 1991 H

THE PROPRIETORS of BRITISH PATENTS Nos. 195,380 and 195,381, for "Improvements in and connected with Machines for Grinding or Surfacing Gear Teeth," DESIRE to INTRODUCE their INVENTIONS to the NOTICE of MANUFACTURERS and others, with a view to the inventions being worked commercially under LICENCE or otherwise.—All communications to be addressed to JENSEN and SON, Chartered Patent Agents, 77, Chancery-lane, London, W.C. 2. 1921 H

THE PROPRIETOR of BRITISH PATENT No. 194,180, dated April 13, 1922, relating to "Improvements in Foundry Moulding Machines," is DESIROUS of ENTERING into ARRANGEMENTS by way of a LICENCE or otherwise on reasonable terms for the purpose of EXPLOITING the above patent and ensuring its practical working in Great Britain.—All inquiries to be addressed to B. SINGER, 28, East Jackson Blvd., Chicago, Illinois. 1923 H

THE PROPRIETOR of BRITISH PATENT No. 157,458, dated April 6, 1918, relating to "Improvements in Means for Recording the State of Motion of Vehicles," is DESIROUS of ENTERING into ARRANGEMENTS by way of a LICENCE or otherwise on reasonable terms for the purpose of EXPLOITING the above patent and ensuring its practical working in Great Britain.—All inquiries to be addressed to B. SINGER, Steger Building, Chicago, Illinois. 1926 H

THE PROPRIETOR of BRITISH PATENT No. 198,451, dated March 8, 1922, relating to "Improvements in Pipe Unions," is DESIROUS of ENTERING into ARRANGEMENTS by way of a LICENCE or otherwise on reasonable terms for the purpose of EXPLOITING the above patent and ensuring its practical working in Great Britain.—All inquiries to be addressed to Mr. B. SINGER, Woolworth Bldg., New York City, N.Y., U.S.A. 1971 H

THE PROPRIETOR of BRITISH PATENT No. 129,953, dated April 5, 1919, relating to "Weight Indicator for Weighing Scales," is DESIROUS of ENTERING into ARRANGEMENTS by way of a LICENCE or otherwise on reasonable terms for the purpose of EXPLOITING the above patent and ensuring its practical working in Great Britain.—All inquiries to be addressed to B. SINGER, 28, East Jackson Blvd., Chicago, Illinois. 2033 H

PATENTS

THE PROPRIETOR of BRITISH PATENT No. 182,581, dated April 11, 1921, relating to "Rotary Hooks or Loop Takers for Sewing Machines," is DESIROUS of ENTERING into ARRANGEMENTS by way of a LICENCE or otherwise on reasonable terms for the purpose of EXPLOITING the above patent and ensuring its practical working in Great Britain.—All inquiries to be addressed to Mr. B. SINGER, Woolworth Bldg., New York City, U.S.A. 2034 H

THE PROPRIETOR of BRITISH PATENT No. 180,507, dated April 11, 1921, relating to "Improvements in Sewing Machines," is DESIROUS of ENTERING into ARRANGEMENTS by way of a LICENCE or otherwise on reasonable terms for the purpose of EXPLOITING the above patent and ensuring its practical working in Great Britain.—All inquiries to be addressed to Mr. B. SINGER, Woolworth Bldg., New York City, U.S.A. 2035 H

THE PROPRIETOR of BRITISH PATENTS Nos. 102,866 and 101,253, relating to "Bottle Washing Machines;" and 101,443, relating to "Improvements in Bottle Feeding Mechanism for Use with Bottle Washing and Filling Machines," all dated April 5, 1916, is DESIROUS of ENTERING into ARRANGEMENTS by way of LICENCE or otherwise on reasonable terms for the purpose of EXPLOITING the above patents and ensuring their practical working in Great Britain.—Inquiries to B. SINGER, Steger Building, Chicago, Ill. 2022 H

THE PROPRIETOR of BRITISH PATENT No. 204,923, dated April 3, 1922, relating to "Improvements in Printing Telegraph Machines," is DESIROUS of ENTERING into ARRANGEMENTS by way of a LICENCE or otherwise on reasonable terms for the purpose of EXPLOITING the above patent and ensuring its practical working in Great Britain.—All inquiries to be addressed to B. SINGER, Steger Building, Chicago, Illinois. 2023 H

THE PROPRIETOR of BRITISH PATENT No. 9138/15, dated June 22, 1915, relating to "Improvements in Toothed Gearing," is DESIROUS of ENTERING into ARRANGEMENTS by way of a LICENCE or otherwise on reasonable terms for the purpose of EXPLOITING the above patent and ensuring its practical working in Great Britain.—All inquiries to be addressed to B. SINGER, 28, East Jackson Blvd., Chicago, Illinois. 2024 H

THE PROPRIETOR of BRITISH PATENT No. 183,290, dated May 10, 1921, relating to "Improvements in Connecting Rods," is DESIROUS of ENTERING into ARRANGEMENTS by way of a LICENCE or otherwise on reasonable terms for the purpose of EXPLOITING the above patent and ensuring its practical working in Great Britain.—All inquiries to be addressed to B. SINGER, Steger Building, Chicago, Illinois. 2025 H

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RAILS AND SLEEPERS
R. H. NEAL & Co. Ltd.
PLANT HOUSE, EALING, LONDON, W.5

FOR SALE, FIRST-CLASS PLANT, USED AND UNUSED.
LOCOMOTIVES, 12in. six-wheeler, 12in., four wheeler, 10in., four wheeler.
5-TON ALL-STEEL STEAM DERRICK CRANE, by Butters, 75ft. jib.
PUMPING SET (ASTER-PULSOMETER), 500 gallons per minute against 220ft. head.
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30 H.P. DITTO.
NEW "HORNSBY" "R" Type OIL ENGINES, 45 B.H.P., 35 B.H.P., 22 B.H.P. From stock at reduced prices.
GRANULATOR, 12in. by 5in. Patent Acme, by Goodwin, Barsby, practically equal to new.
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THREE BELLISS and MORCOM GENERATING SETS, 175 K.W., 100 K.W., 97.5 K.W.
HORIZONTAL PUNCHING and BENDING MACHINE.
75 H.P. "NATIONAL" Z.A. Type GAS ENGINE.
CONCRETE MIXER (RANSOME), ½ yard.
MORTAR MILLS with ENGINES combined.
PORTABLE RAILWAY MATERIAL at competitive prices, large stocks on hand.
CRANE SKIPS, ½, ¾, 1, and 1 yard capacity.
JOSEPH PUGSLEY and SONS, Ltd., Lawrence Hill, Bristol. Ex.

FOR SALE.

THREE 5-TON ELECTRIC GANTRY CRANES,

by Holt and Willetts. Spans 21ft. 3in. and 23ft. 10in. Motors by Vickers for 220 volts D.C

Full specification and price on request.

HUGHES, BOLCKOW & CO., LTD.,
THE AERODROME, MARSKE-BY-THE SEA, YORKS.

FOR SALE

FOR SALE.

1. ONE 68 K.W. Steam-driven Direct-current SET, comprising:—
Totally Enclosed High-speed Compound Inverted Vertical Engine, by Browett, Lindley and Co., Patricroft.
High-pressure Cylinder .... 7¼in. bore
Low-pressure Cylinder .... 12½in. bore
Stroke.... 6½in.
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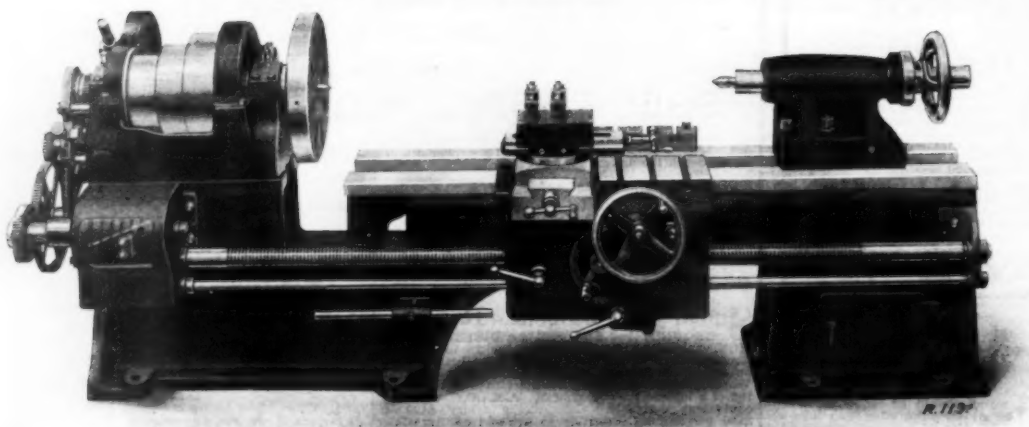

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Battleship Refits.

SINCE the numerical strength of the battle fleet is restricted by the Washington Treaty, it is natural that the Admiralty should desire to maintain such ships as we have in the highest possible state of efficiency. To this end a fairly large programme of reconstruction is being carried out. In recent years the five ships of the "Royal Sovereign" class have been fitted with anti-torpedo bulges, while important additions have been made to the armour and underwater protection of the battle-cruisers Repulse and Renown. A start has now been made with the work of modernising the five "Queen Elizabeth" battleships, the Warspite being the first to undergo this process. She is to be commissioned at Portsmouth next Tuesday to relieve the nameship of the class as flagship of Admiral Sir Roger Keyes in the Mediterranean. The Warspite's appearance has been completely altered by the reconstruction. The most striking change is in the position of the funnels, which are now trunked together, the base of the first funnel having been curved backward and cased-in with that of the second. By means of this arrangement, the navigating position and the fire control stations in the forward part of the ship are kept free of funnel smoke. It is understood that the other four ships of the class will be treated in the same way, and will also receive bulge protection. It is apparently not intended that the five oldest units of the battle fleet—the four "Iron Dukes" and the Tiger—shall undergo extensive refit, as these vessels are due to be scrapped in 1934–35. The "Iron Dukes" are now to be formed into a training squadron for boys, and will be attached to the Atlantic Fleet.

Two Important Motor Ship Orders.

THE feeling of quiet optimism which was characteristic of the first meeting of the Institution of Naval Architects last week, when the future of the British shipbuilding industry was discussed, will be strengthened by the announcement that the order for two large motor passenger liners has been placed by the Shaw, Savill and Albion Company, Ltd. The new vessels, each of 20,000 tons gross measurement, are for the owner's New Zealand service, and will be built, one by the Fairfield Shipbuilding and Engineering Company, Ltd., at Govan, and the other by Swan, Hunter and Wigham Richardson, Ltd., of Wallsend-on-Tyne. Both vessels will be quadruple-screw ships, equipped with Sulzer type marine oil engines, which will be constructed by the Fairfield Company and by the Wallsend Slipway and Engineering Company, Ltd., respectively. The engines of each ship will have a total shaft horse-power of about 16,000, and will be designed to run at a speed of round about 117 revolutions per minute, propelling the vessel at 17 knots. The passenger accommodation, we understand, will be on generous lines, and the speed of the ships will be such as to reduce the voyage from London to Wellington from thirty-seven to twenty-nine or thirty days, thereby saving a week. We understand that there was keen rivalry among British builders, both for the ships and the propelling machinery.

The Electricity Supply Bill.

ON Monday last the Council of the Institution of Electrical Engineers sent a letter to the Prime Minister concerning the Electricity Supply Bill now before Parliament. After full consideration of the Bill and the Weir report, the Council has come to the conclusion that certain of the provisions in the Bill require material amendment, as they are based upon an imperfect knowledge of all the facts, and if embodied in the Act might be detrimental to the national interest. The Council therefore considers that it is of the greatest importance that the fundamental questions upon which the Bill is based should be the subject matter of an inquiry, at which the various interests in the electrical industry should be heard before the Bill becomes law.

Salvage of Sunken Warships.

THE news that on Saturday last Cox and Danks, Ltd., lifted their twenty-third destroyer at Scapa Flow is of interest, because with the raising of that vessel only two of the smaller ships remain to be dealt with. Already, we learn, salvage work has been begun on the large battleship Hindenburg. The success of Messrs. Cox and Danks at Scapa Flow has doubtlessly turned the attention of other nations to the prospect of raising sunken warships. From Constantinople it is announced that the Turkish Government has fixed a contract with the firm of Fratelli Sera for the salving of all warships and transports which were sunk in the Dardanelles. According to *The Times* correspondent in Constantinople, under the contract, 90 per cent. of any money extracted from the ships will go to the Turkish Government, as well as 30 per cent. of the effects. It is also agreed that the Government will have the right to acquire any vessel which may be salved, while ships which are not wanted may be sold to a third party. It is understood that the vessels sunk in the Dardanelles comprise some thirty-nine ships. Among the larger British ships included in this number are the Irresistible (15,000 tons), Triumph (11,985 tons), Ocean and Goliath (12,950 tons), and Majestic (14,900 tons). Added to these vessels is the French battleship Bouvet (12,000 tons), besides smaller naval craft and Allied and Turkish transports. The salvage programme contemplated would appear to be an extensive and difficult one.

Waterloo Bridge.

ON Tuesday the London County Council had submitted to it a report by its Improvements Committee regarding a competition for designs for a new Waterloo Bridge. It has already been decided by the Council that the bridge should have not more than five arches over the river, and be wide enough to accommodate six lines of vehicular traffic. The Improvements Committee reported that in its opinion the conditions to be laid down for the suggested competition should be such as to leave the fullest possible scope for those taking part in it to exercise their taste and ability. It proposed that, in addition to the Council's requirements as to width and number of arches, the competitors should be bound only by the necessity for adhering to prescribed levels for the roadway, the minimum width of spans and headroom for navigation purposes, and general relationship of the design with the design of neighbouring buildings. The competition, it was submitted, should be open only to British subjects. Four assessors should be appointed in connection with it. One, it was suggested, should be Mr. G. W. Humphreys, the Council's chief engineer. The President of the Institution of Civil Engineers should be invited to appoint another, and the President of the Royal Institute of British Architects the remaining two.

French Naval Construction.

THE results obtained by French naval architects and engineers in the construction of the new war vessels which have passed through their trials, are declared by M. Georges Leygues, the Minister of Marine, to be highly satisfactory. Speaking before the Commission of the Marine, he stated that for eight years makers of special material required for the building of warships had supplied nothing, and might therefore have been expected to have fallen behind in the production of the still higher quality of material needed nowadays. Engineers and architects found themselves confronted by entirely new problems, for which they had not been prepared by gradual developments. They had gone, he said, without transition from the "Ernest-Renan" type of cruiser, with engines of 36,000 horse-power and a speed of 24 knots, to the Duguay-Trouin, with 100,000 horse-power engines and 34 knots and to the Duquesne with 130,000 horse-power and 36 knots. It is true that there had been delays in carrying out the trials, and that there had been certain minor accidents, traceable largely to the failure of materials, which, on account of lack of experience on the part of the makers who had supplied practically nothing for warship construction since 1914, did not come up entirely to specification. Nevertheless, the mishaps during trials were not regarded as exceeding those taking place in any other navy, and the final result was that several ships had done much better than had been expected in the way of speed and endurance. The Minister therefore regarded the new light and fast cruisers as of great value and as an indispensible nucleus for the reconstitution of the French Navy.

The Cierva Autogiro.

WE are informed that a company with the title the Cierva Autogiro Company, Ltd., was formed last week for the purpose of undertaking research work connected with Señor Juan de la Cierva's "autogiro" or windmill flying machine, and of disposing of the construction rights of the invention. The directors of the new company are Mr. J. G. Weir, Señor de la Cierva, and Mr. H. K. M. Kindersley. Mr. F. T. Courtney has been appointed technical manager. Mr. Weir is a director of G. and J. Weir, Ltd., of Glasgow, and has for a long time taken an interest in the development of aviation. Señor de la Cierva, a Spanish engineer, is the inventor of the "Autogiro," and has been studying aeronautics since 1910. Mr. Kindersley is the son of Sir Robert Kindersley, the well-known banker. Mr. Courtney is one of the best known of British pilots, and was in charge of the "Autogiro" machine demonstrated at Farnborough last autumn.

Quay Improvements at Sunderland.

IT is expected that work will shortly be begun on a new deep-water riverside quay and warehouse at Sunderland. The scheme has been prepared by the Sunderland Town Council, and has been under consideration for a number of years. It has now received the sanction of the Unemployment Grants Committee, and a Government grant of 50 per cent. of the interest and sinking fund on the whole expenditure over a period of the first fifteen years has been agreed to. Statutory powers will be sought by the Sunderland Corporation, but meanwhile the work will be carried on by the River Wear Commissioners. The scheme provides for the construction of a deep-water quay, 600ft. long, near the mouth of the river Wear, which will be connected by rail to the South Dock. In addition, a large warehouse, 300ft. by 90ft., will be built at the back of the quay, the top floor of which will be on a level with the High-street. It is proposed to install cranes and electric lifts, so that goods can be transferred from the quay-level to the top of the new warehouse. The execution of the work, it is stated, will occupy about three years.

The Production of Fuel Alcohol.

ADDRESSING a meeting of the Farmers' Club in London on Monday, Mr. G. W. Monier-Williams, of the Ministry of Health, discussed the possibilities of producing fuel alcohol on a large scale in this country from vegetation. The picture he presented was not a very encouraging one. The advantage of obtaining a liquid fuel from a source that could be renewed year by year was, he said, offset by the smallness of the yield recoverable from any of the vegetable materials available. From potatoes only about 7 per cent. by weight of alcohol could be obtained. Cereals yielded 13 to 16 per cent. of the weight of grain and straw together. Timber gave but 5 to 7 per cent. of its weight as felled. The actual cost of fermenting and distilling the materials was not high. In 1920 it was estimated at about 9d. per gallon of alcohol produced, and to-day it would probably be about 5d. or 6d. But the cost of growing, harvesting and transporting the raw material with such a large percentage of its weight valueless for the production of alcohol would, Mr. Monier-Williams stated, make it difficult to produce the fuel at a figure much below 3s. per gallon in bulk at the factory. To that figure would have to be added the cost of denaturing, distribution and overhead charges, &c. In the opinion of many authorities, these facts suggested that liquid fuel produced direct from coal rather than from vegetation would be the fuel of the future.

Great Eastern Train Ferries.

THE train ferry service between Harwich and Zeebrugge, operated by means of three of the ferries used by the British Government during the war for the carriage of munitions between Richborough, Southampton and France, began work in the last days of April, 1924. Each vessel can accommodate fifty-four laden 12-ton trucks. During the first eleven months of the service the total traffic handled amounted to 40,049 tons, of which 38,595 tons represented imports. The eleven months' working resulted in a loss of £25,334. At the annual general meeting of the company, Great Eastern Train Ferries, Ltd., last Friday, March 26th, the chairman, Lord Daryngton, was in a position to paint a brighter picture. In the eight months to December, 1925, the service had, he said, handled 72,473 tons of traffic, of which 65,600 tons represented imports, and had earned a profit of £4754. The returns for the first two months of this year, he added, showed that the progress, both as regarded traffic and profit, had been maintained. The ferries continue to derive their chief support from the transport of perishables, such as fruit and farm produce and fragile materials, as, for example, bricks and tiles. An order for eighty-five continental railway vehicles placed in this country is now in course of shipment by way of the service. The ferries have been converted from oil to coal burners, and, according to Lord Daryngton, the anticipated saving of some £14,000 a year is now being realised as a result of this change. Provision has been made for reverting to oil fuel at any time.

Institution of Fuel Technology.

FOLLOWING upon the largely attended meeting, to discuss the formation of an Institute of Fuel Technology, held on March 5th last at the Institution of Civil Engineers, London, the organising committee appointed thereat held its first meeting on Tuesday, March 23rd. It was definitely decided to adopt the name "Institution of Fuel Technology," which covers the wide field of activities the new Institution will represent. The organising committee is extending invitations to other organisations to be represented, and Lord Montagu of Beaulieu has already intimated his intention to join the Committee. A sub-committee was appointed to draft with all speed a constitution and by-laws, and held its first session on March 26th. It will meet at least once a week until the work is completed. This draft constitution will then be considered in detail by the organising committee, and eventually a copy will be sent to everyone interested, for consideration, prior to a second public meeting, which will be called to adopt or amend it as the potential members may think fit. We are informed that the support so far received has exceeded all expectations and is ample evidence of the urgent need for one strong and influential organisation to deal with the subject of fuel of all kinds. The hon. secretary (*pro tem.*) is Mr. Edgar C. Evans, Caxton House (East), Tothill-street, Westminster, S.W. 1.

Traditional Architectural Forms and Their Structural Efficiency.

By WILLIAM HARVEY.

BOTH architecture and structural engineering are concerned with the design of buildings of sufficient strength and endurance for the purposes they are meant to serve, and both architect and engineer may with propriety, improve the artistic effect of their structures by choosing the elements of which they are composed, and assembling them in pleasant forms, without the sacrifice of efficiency. Architecture and engineering part company in practice at the point where masses of material, unnecessary for the strength or convenience of the structure, are added by the architect for purposes of ornament, or where the engineer's structurally sound framework is so designed that it only satisfies the conditions of stability, and is built with an utter disregard of appearance.

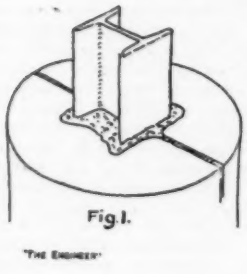


Fig. 1.

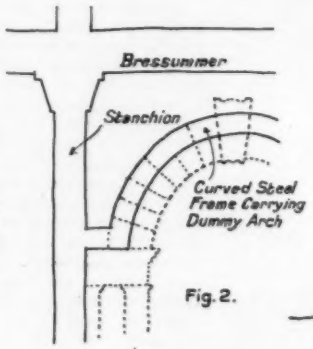
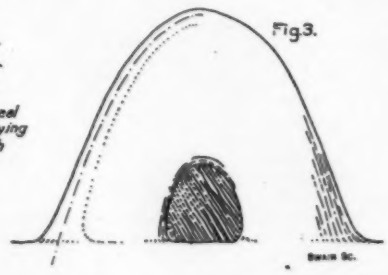


Fig. 2.



Greater harmony of effect ought to exist between works of architecture and works of engineering, which have to exist and be seen together under our modern conditions. One serious stumbling block in the path of unity is the architect's adherence to ornamental and even to structural forms, which were originated in the distant past, and which have little or no reference to present-day methods of construction. In some few instances the ornamental traditional shapes which have been dragged by the architect out of their graves in the ruins of Egypt, Greece, or Rome afford some practical advantages to compensate for their additional cost and weight; in many other cases they are useless, or even disadvantageous and structurally dangerous.

The stone or marble casing in the form of a column which encloses a steel stanchion may protect the metal from decay by rusting or from the effects of fire, or by insulating it more or less efficiently, may preserve it from changes of temperature or accidental blows—always provided that the casing is applied in an effective manner—Fig. 1. This excuse cannot be claimed, however, for an ornamental stone arch introduced in a steel-framed building where an additional weight of steel falsework has to be elaborately built up to an arched outline to support the dummy voussoirs. The extra complication of parts involves an expense not warranted by the structural necessities of the case, and amounts to a slight defect from the practical point of view. From the aspect of sound art such an arrangement is even more pernicious, for dummy productions are inevitably pretentious, or dull, or both—Fig. 2.

Supposing, however, that the architect resolves to abandon shams, such as stone arches suspended upon a steel framework, and confines himself to genuine masoncraft, he at once finds that the fetters of a past style restrict his designing powers. The engineer building a masonry railway bridge or viaduct feels free to design the curve of the arch in the most suitable manner to support the loads and to meet the conditions of headroom, fairway and gradient. Even if he does not design on catenary principles, the hyperbola and parabola, and various cycloidal curves are at his disposal, as well as the semi-circle and the ellipse. The unfortunate architect is confined to the use of certain traditional shapes on pain of appearing unconventional, and this limitation certainly does not make for sound construction.

Architectural forms have become established on a basis of tradition rather than of reason, and the origin of the tradition may date back to the primitive experiments of a semi-savage people. Strangely enough, the savage originators of arched construction seem sometimes to have produced forms of great structural merit. The thimble-shaped mud hut and the arch curved to the contour of the small end of an egg are to be seen in Egyptian and Babylonian sculptures, and such buildings must have utilised the compressive strength of the material to a highly satisfactory degree. As long as such arches and domes are erected with the curve of their contour springing from a solid foundation, they approximate to the ideal shapes for arch structures, and in them rule of thumb and rational theory take a parallel course—Fig. 3. The desire to elevate the arch upon a vertical wall, or pier, in order to provide increased headroom without increase of span, introduced into architecture a most pernicious and unconstructional type of design. Instead of the axis of the material construction following the line of arch thrust and rising in a regular curve from the foundations to the crown of the arch, it departs from that curve in what is really an exterior bulge near the top of the vertical pier—see Fig. 4. In a masonry construction the effective arch action begins at a point X far underground where the pressures obtain a foundation and abutment. S indicates the approximate natural line of pressure, and R the architect's line of resistances. The spaces A A′ between the line of pressure and the line of resistances increase as the building distorts under its load. The distortion S′ in the building automatically moves the natural line of pressures into a series of positions less and less favourable to stability. Hair cracks C in the pier and arch are signs of disintegration of the masonry produced as a result of the long continued movement.

A simple practical test illustrates the evil effect of this traditional architectural form, for a model made of damp clay or plasticine or of uncemented blocks of wood or cork will show in a comparatively short time that the arch tends to become depressed at the crown and to spread at the haunches, while the piers tend to overturn outwards at their tops. The whole model, in fact, alters in shape, and although the material of which it is constructed affects the nature and the extent of the alteration to a slight degree, the direction of the movement is consistent in the main, whatever material is employed. Given a plastic model of a semi-circular arch raised upon vertical piers, the effect can be produced by simply leaving the model to sink under its own weight without additional pressure. Models of loose blocks may not produce such fluent curves, but the sliding and tilting of the blocks upon their bed joints corresponds remarkably closely to the distortions and flexures of the plastic model.

Some important inferences may be deduced from this constant action of composite architectural forms consisting of arches and vertical piers. First, as regards the natural forces of gravitation, an arch must be considered to begin its ideal line of thrust at the level at which it finds solid foundation and abutment, and this level may be deep in the earth below and beyond the artificial foundations composed of masonry or concrete. Movement or yielding in the earth base affects the arch as a whole, allowing its crown to descend and its span to increase. In an ordinary architectural "arch-on-piers" construction, it also permits the piers to hinge and rock, and hastens the deformation of the whole.

In the second place, wherever the centre of resistance of the material of which the arch is formed lies to one side of its ideal curve, movements are liable to take place in the same direction. Each successive distortion not only adds to the total deflection, but accelerates the production of further movements. A clear illustration of this tendency of the masses to move in certain definitely recognisable directions may be obtained by means of a model arch composed of a series of hollow voussoirs arranged to lie with the ideal line of thrust passing through the hollows in the voussoirs. The pressure of the arch soon makes its effect apparent in the distortion of the hollow voussoirs, which tend to compress and flatten in the direction of the line of thrust and to elongate in a direction normal to it. A model of an arch with hollow voussoirs is indicated in Fig. 5. The material tends to spread outwards at A A and to compress at B B. In the case of a plasticene model which was kept under observation, the descent of the crown took place at the rate of $^1/_{32}$in. in four days under the action of its own weight alone.

Both models and full-size buildings erected to the traditional architectural forms show progressive distortions of a consistent character in accordance with this rule. If the architect has provided masses of material in positions upon one side or other of the ideal line of thrust, these masses inevitably tend to drift further and further from it. Nature seems to reject the ill-placed material, and in process of time the piers and buttresses of an arched building are found to have become bent in every part in accordance with the internal stresses set up by the arch pressures. These delicate curves may be seen quite easily with the naked eye at Westminster Abbey, particularly in the great central piers, and less distinctly at St. Paul's Cathedral, where the architectural mouldings and carvings obscure the outline of the piers to some extent.

This little understood tendency of imperfectly shaped arches to move slowly towards their fall has an important bearing upon the design of new buildings, but the tendency is still more harmful in old buildings which have already undergone considerable distortion in the course of centuries and are already in a weakened state. It is therefore vitally important that the custodians of old arched buildings should be aware of these consistent movements which are easily comprehensible when once their origin in imperfect arch and buttress design is pointed out. The fall of an important historic monument is not a matter of frequent occurrence, but whenever a great arched building does fall, the event comes as a surprise not only to the public, but also to the custodian for the time being, whose duty it is to uphold the structure by shoring or other means and to keep it in a state of stability.

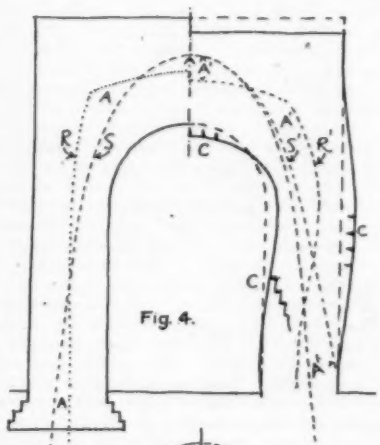


Fig. 4.

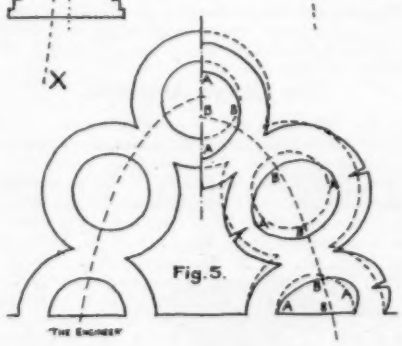


Fig. 5.

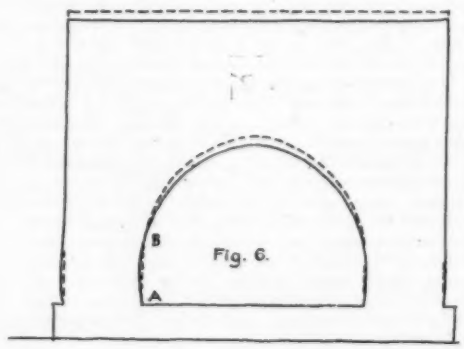


Fig. 6.

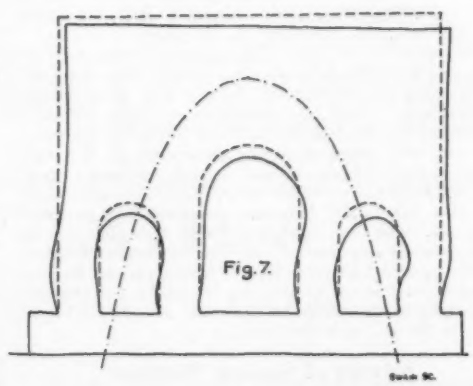


Fig. 7.

The central tower of Chichester Cathedral, which was built, like most other central towers of cathedrals, upon arches raised upon vertical piers, fell suddenly and unexpectedly in this way, although a famous architect was in charge and was executing repairs to other parts of the fabric. Even timber for shoring was at hand, but failure to recognise the serious meaning of slight signs of decay prevented its erection until too late to save the tower.

England is rich in fine Romanesque and Gothic Cathedrals built during a period of 400 years between 1100 and 1500 A.D., and many of them include high and heavy central towers built upon piers and arches at the intersection of nave and transepts. Practically everyone of these towers is really undergoing at the present moment a very slight and slow, but continuous and progressive, distortion in accordance with the adjustment of the masses of material under the arch pressures. These distortions must inevitably be accompanied by the weakening of the material of which the piers are built, and the ultimate fall of each tower is only a question of sufficient time. Many of them have already endured for several centuries, and their periods of stability must be drawing near their end. In the case of Chichester tower, the indifferent lime and rubble concrete composing the interior of the piers was blamed for the collapse.

The part played by progressive distortions and adjustments in the imperfectly designed and imperfectly buttressed arches has not hitherto been recognised, and the exact analysis of pressures in the complex arrangement of piers, arches and buttresses which compose a typical Gothic cathedral is an affair for prolonged and unremitting study. The preliminary stages of such an investigation may be made and useful ideas as to the principal tendencies of the building obtained, by the use of models which will show how the composite arrangement of small arches across the aisles combines with the high vault across the nave to form what is really one composite arch rising from dual foundations on each side of the axis of the building. The model illustrates the fact that

Fig 8.
Tensile Reinforcing Hoops at A B C

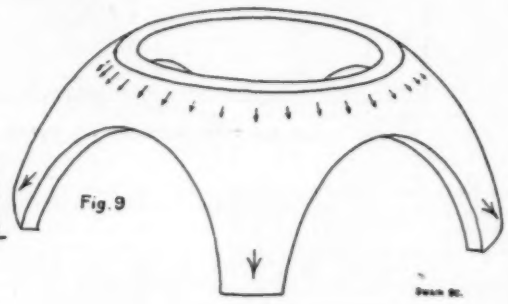


Fig. 9

the pier and buttress, which stand on the inner and outer side of the aisle respectively, are subjected to stresses which cannot be simply expressed by the commonly accepted architectural explanation, "the pier takes the vertical weight and the buttress resists the thrust." The model shows, in fact, that the two supporting members, the pier and the buttress, are each taking a share of loading of which the effect, in weight and thrust combined, would have been brought safely to rest in a symmetrically designed foundation had the composite arrangement of arches, pier and buttress been replaced by a single well designed arch ring of suitable curvature.

The comparatively simple form of a Roman triumphal arch resembles the section of a Gothic cathedral in its arrangement of one large and high arch with a smaller and lower arch upon each side, and the effect of pressure is well illustrated in Fig. 7. This engraving shows the original outline of a plastic model of a triumphal arch in relation to the outline assumed by the same model at a later stage when its natural distortion has become pronounced, but before collapse has taken place. Although, architecturally speaking, there are three arches, the distortions take place with reference to an imaginary single arch indicated by the chain-dotted curve. The line of pressure is forced to divide into two components above the crown of each subordinate arch, and produces curvature in all the four supporting piers. As was seen in the case of Fig. 5—the arch with hollow voussoirs—the supporting masses which lie to either side of the ideal simple line of thrust have moved still further away from it, and the piers which are supposed, according to the old theory, to be "bearing the vertical weight," are found to be bent as well as the buttresses, or exterior piers, which were admittedly taking the lateral "thrust." The inward direction in which the piers are bent is noteworthy, for it is characteristic of the deflection of the piers in most Gothic Cathedrals that have been provided with a high nave and low aisles.

The benefit of disposing the masses of material more nearly in accordance with the ideal single thrust line is shown in Fig. 6, which illustrates a model of the same size as that shown in Fig. 7, but having two instead of four piers and one arch equal in span to the three spans of the triumphal arch. Very much less subsidence and distortion are produced in the same time. The distortion would have been still less had the supports not been vertical from A to B. Not only is the distortion less, but it is of a simple instead of a complex character.

In most Romanesque and Gothic buildings the supporting members are extremely attenuated in substance, and the effective bearing area of piers, walls and buttresses is often still further reduced by the unequal bedding of the external casing of wrought stonework, and the more compressible rubble concrete with which the interior is filled. The effect of excentric loading in reducing the safe allowable unit load upon a steel stanchion now receives the attention of all structural engineers as a matter of course, and this far more complex and dangerous distortion of heavily, excentrically and obliquely loaded masonry piers should no longer be completely ignored by the custodians of our cathedrals. At one Gothic cathedral which has been found to be distorted and cracked in many parts, a grouting scheme has been put in hand before any complete survey has been made to ascertain the connection of arch pressures with the direction of movements.

The suggestion of an earthquake as the cause of cracks and distortions really begs the question, for the cracks produced in a complex arched building by any earthquake of insufficient force to cause its collapse will take place in the same positions as cracks occurring in the course of years or centuries under the influence of the arch pressures without the earthquake. In 1908 the author measured the domed Mosque of Eski Serail, Salonica, where the distortions, attributed to the effects of earthquake, are most interesting, as showing the interplay of arches, domes, pendentives and semidomes mutually supporting and partially and imperfectly buttressing each other's thrusts. The building, with its central span of 20ft., is small compared with our cathedrals, but takes an intermediate position between a large building and a model. The consistent yielding and bending of all parts under the arch pressures would be represented faithfully by the behaviour of a plastic model settling under its own weight, though artificial rocking of the baseplate of the model to produce a miniature representation of an earthquake would undoubtedly accelerate the action.

Given an arched building of ordinary architectural form, with the arches elevated upon vertical supports, the inherent defect due to the departure of the line of resistances from the ideal line of thrusts is so grave as to dominate almost all other causes of decay. The characteristic distortions of the supporting and buttressing masses are seldom or never suppressed and are almost invariably increased by other accidental sources of damage. The failure of an arched building, almost without exception, takes place in relation to the action of its arch thrusts. Thus, a weak foundation permits a buttress already subjected to overturning moments to move and overturn more freely by hinging at the base.

Wind pressure increases the effects of arch thrusts upon one side of a building, while diminishing them upon the other, and the fluctuations in stress carried on over long periods undoubtedly have a pernicious effect upon the strength of the material, and consequently upon the distortions of the masses, since every stage in the decay of the supports is both preceded and followed by stages in the descent of the arch.

Vaults and domes of the usual architectural forms when elevated upon vertical supports share with arches some of their tendencies to cause continuous and progressive distortion in the structure. A dome is a particularly stable form of building, in that its broad continuous band of base receives its load and lateral thrust in distributed form, and its circular plan also affords an opportunity for the introduction of an effective tensile chainage or series of metallic hoops—Fig. 8. These advantages have to be foregone, however, when the dome surface is penetrated by arches, and the diffusion of weight and thrust is again concentrated on their springings—see Fig. 9. Those portions of a domical surface which descend in the shape of spherical triangles between the haunches of pairs of arches meeting upon the top of a pier or column, and which are known to architects as "spherical pendentives," are just as dangerous as an unbroken dome is stable. Even supposing the weight of the dome or drum built above the pendentives to be received by them in the form of a diffused vertical load, as it may be if these architectural superstructures are effectively chained, and no breath of wind is permitted to blow, the resultant thrust at the foot of each pendentive is not only a concentrated load, but reaches the support in an oblique direction and demands an extraordinary amount of buttressing to ensure stability.

A model of a spherical pendentive supporting a loaded drum and elevated upon vertical piers proved most instructive on this point. The model was made of clay and supported a heavy load for several weeks with a slight and continuous bending of the supports at the springing. Cracks which opened at the points of convex curvature were repeatedly filled in with moist clay, a process similar to "grouting" in practice, but persistently opened up anew. After two months of extremely gradual decay, the model suddenly collapsed, although the load had been removed when the signs of movement and distortion became noticeable. In its very slow failure and its momentary fall, the model indicates with undeniable accuracy the fate of many an ancient building in which traditional architectural forms have been employed without sufficient regard to their structural fitness. Comparatively insignificant distortions and fractures transformed the model from a compact frame capable of supporting several pounds weight to a dilapidated and weakened structure incapable of supporting itself, and this same degradation of the strength of a structure goes on in the full-sized building in the course of centuries.

In some advanced cases of decay it is possible to measure the actual rate of movement when one part of a building remains approximately stable and other parts are drawing away from it; but, in general, the movements are so slight and affect the building in such a consistent and harmonious fashion that they elude observation. So much is this the case that the distortions they produce have frequently been ascribed to the superior artistry of ancient architects, who have been praised by enthusiastic amateurs for having deliberately built their walls and piers in slightly curved forms where modern architects would be content to design in straight lines!

Patient analytical surveys are needed if the effects of time and the efforts of curve-loving architects are to be differentiated from one another in the case of any particular monument. Every distortion and fracture must be charted and the behaviour of loaded models studied in order to see whether such distortions are likely to be produced under the conditions of shaping and loading to which the building has been subjected.

The Report on the Coal Industry.

By PROFESSOR HENRY E. ARMSTRONG.

THUS far, the report of the Royal Commission has been considered by the Press mainly with reference to economic issues. There has been little comment upon Chapter III., "Utilisation of Coal," and Chapter IV., "Research." Yet the former is probably the keynote of the situation, as the economic position of coal, in the not far distant future, probably will depend almost entirely upon the treatment it undergoes prior to use as fuel. It is most unfortunate, to say the least, that science was unrepresented upon the Commission and that no attempt whatever was made to elicit the opinion and use the considerable knowledge of those who have made a scientific study of fuels and the treatment of coal. Not a single such witness was called. This attitude is but symptomatic of the ignorant manner in which we have hitherto treated our coal. It has never been regarded as more than so much "stone" to be burnt; the price to be obtained and paid for it as fuel has alone been considered.

The pollution of the atmosphere, through smoke from coal burnt raw in the domestic grate, is necessarily referred to but with the implication that we only need to prevent soot from escaping. If soot were abolished it is true that we should not have black fog, and the town atmosphere would be less laden with dust, but much flue dust would still be emitted and acid products would escape from our fires, which would induce fog, irritate the lungs and attack stone and metal work. We need to do much more than merely prevent visible smoke. If we are ever to use coal rationally, we must cleanse it, as far as possible, before attempting to burn it. Until and unless the nation realises that this is the first charge upon the mining industry, there will be no progress. Coal must be made into a manufactured article. We have only to consider the amount of money wasted in carting dirt, under the guise of coal, about the country. Coal carries up to 10 per cent. on the average of mineral, incombustible matter; 250 million tons of coal per annum mean perhaps 25 million tons of rubbish, carted backwards and forwards, about the country, to no purpose, thrown upon fires and into furnaces, lifted from these as ashes or clinker, which in turn must be conveyed to the dust dump. We can only reduce such unpardonable waste to a minimum by cleansing our coal at the pit mouth. As a preliminary to such improvement, the coal must be reduced to a suitable state of division. This means that simple drilling methods might be used in the mine, whereby the coal would be directly produced in the state of division suitable for immediate further treatment,

either by sedimentation or flotation processes, to reduce sulphur (pyrites) and stoney matter to a minimum.

Coal thus purified could also, there and then, be carbonised at a low temperature and so converted into a compact fuel which could be used with advantage in households. Alternatively, it might be made into a powdered carbonised fuel suitable for steam raising. The only possible alternative to oil fuel is powdered fuel. We have done little to develop the use of coal in this form. Our engineers are too conservative and their outlook is not sufficiently theoretical. Probably the average value of the coal from a mine could be raised, and raised considerably, by such treatment, as slack commands but a low price.

In carbonising coal a moderate amount of high-quality gas and a good deal of oil will be produced. The gas must find local use and probably could be piped to some distance, if necessary. No exaggerated value must be set upon the oil. It will be totally unlike the coal tar now made by the gas companies and no substitute for it. The amount of ammonia obtained will be small and no dyestuffs will be producible from the oil. It can either be used as a whole in the Diesel engine or burnt as a whole. When it is distilled, its liquid value is largely sacrificed, as it is about half converted into a brittle solid, which has none of the properties of pitch.

The Commissioners appear to have been misled by Dr. Lander, to judge from the statements made on page 25, where they say: "We have given close attention to the question of low-temperature carbonisation, but we can find no evidence that the system has yet been anywhere established on a commercial scale for a period sufficiently long to enable the claims that are made on its behalf to be fully tested."

This does not represent the facts. A plant was run continuously at Barnsley during considerably more than a year, in which about 50 tons of coal were carbonised daily and converted into a domestic fuel of the most satisfactory kind, together with gas and oil. The experiment was reported upon most favourably by Dr. Lander's staff, but the Fuel Board had neither the courage nor the nous to point out how nearly satisfactory the plant was from an economic point of view. Ramshackle, in a sense, as the installation was, built by people who had little knowledge of gas technique, without any attempt to secure economic working and the prevention of heat losses, it yet worked and worked well. It was gas-tight and oil-tight, and the solid fuel was all that could be desired. I have used the fuel during the two past winters, with great satisfaction; but my sweep complains that there is no soot in the chimneys.

The Commission recommend "that the Government should give sympathetic consideration to any proposals of the Fuel Research Board for the further investigation of the process on a commercial scale."

The Fuel Research Board has done nothing thus far but discourage those who have done their best to develop low-temperature carbonisation. Had the Board had the nous to appreciate what was being done, the prime importance of solving the problem without delay, the possibilities of the method, commercial success would long ago have been reached. In fact, the Board has not only wasted half a million of public money but has discouraged the efforts of those who have sought to develop suitable methods. The one thing the Board should have done, but has never done, was to insist on a proper scientific treatment of the problem. Success will only be reached when skilled chemist and engineer lay their heads together and together devise suitable plant. Thus far, the engineer alone has been engaged on the work; the problem is very largely chemical and, in part, entirely beyond the grasp of the engineer. The attempts that have been made, therefore, in a sense, have all been muddled attempts, but so nearly successful that it is clear that success could be attained under competent management. The problem is only to be solved by working on a commercial scale under commercial conditions.

Investigation of processes through a Board will be useless. A national supervisory body is spoken of in the report. Heaven preserve us also from any such body. The men with the necessary knowledge, freedom from commercial prejudice and sufficient breadth of outlook who could so act are not yet available. What should be done is to insist that the mineowners themselves, within a specified time, undertake the task. Let them form an advisory body. Thus far, not a finger has been lifted by owner or larger user to help in the improvement of coal. The one and only desire has been to sell as much as possible; economy in use has been the last thing thought of as desirable, especially in towns such as Sheffield.

What the coal industry most needs is the introduction of the scientific spirit into all its operations. No other industry is so inefficient. Let nationalisation be held out as the supreme penalty to be exacted, at no distant date, if the industry do not forthwith set to work and itself put its house in order. In some way it must be put upon its mettle. The possession of coal should carry the obligation to treat it rationally. This has never yet been recognised.

Hydraulic Developments of the Midi Railway in the Ossau Valley.

The Midi Railway, which operates in southern France in a district stretching from Bordeaux to Bayonne and the Spanish frontier, and from the Garonne to Narbonne on the western side of the Gulf of Lyons, has for some time past been developing the water power resources of several watersheds on the north side of the Pyrenees in order to obtain current for electric traction, and to a lesser degree for the supply of surplus power to towns and villages along its route. Some particulars of the electrification scheme were given in our issue of October 23rd, 1925.

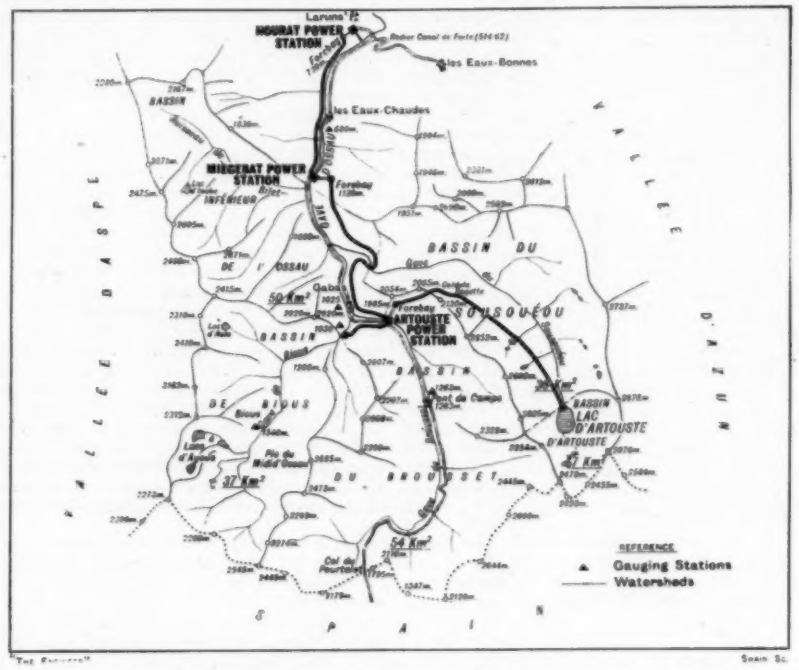


FIG. 1—MAP SHOWING POSITIONS OF POWER STATIONS IN THE OSSAU VALLEY

Extensive developments in the valley of the Ossau and its tributaries are now nearing completion. In this region—see Figs. 1 and 2—three power stations have been arranged for, one below the other. The watershed runs up to the summit of the ridge which forms the frontier with Spain. The lowest of the three stations, that at Hourat on the outskirts of Laruns, is now in operation, the middle station at Miègebat, not far from the watering-place of Eaux-Chaudes, is practically completed; and the upper, or Artouste, station is in progress. The supply for the last-named station is to be taken from the Lake of Artouste, which lies in a hollow, with mountains on three sides, some of which reach to a height of nearly 10,000ft. The size of the lake has been increased by raising the level 67ft., and transforming it into a reservoir with a capacity of about 810 million cubic feet.

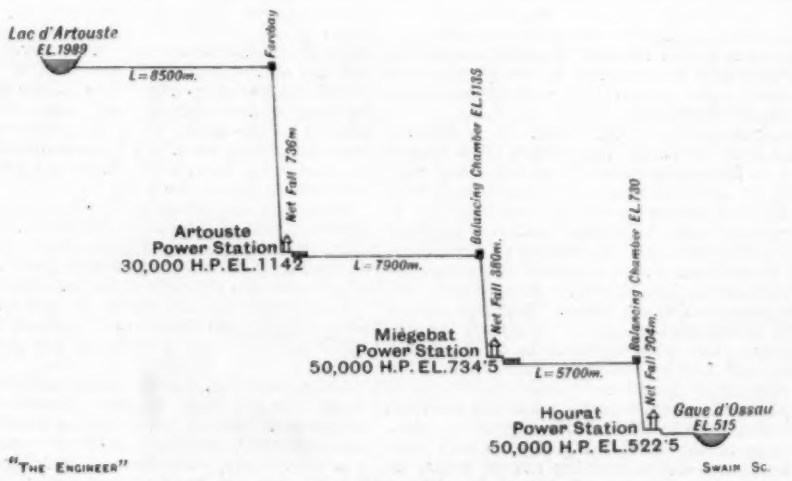


FIG. 2—DIAGRAM SHOWING RELATIVE POSITIONS OF POWER STATIONS

The Artouste station takes its water at 6456ft. above sea level, and discharges it at 3707ft. The second station at Miègebat draws the water direct from the tail-race of the first and discharges it at 2394ft. The third, Hourat, takes the water at the second tail-race level and discharges it through a tail-race tunnel into the river Ossau near Laruns at a level of 1696ft. There are several small reservoirs below the head sluices, and in the case of the two lower stations water from the side valleys is used to reinforce that which is discharged from the station above. The quantity of water handled at Hourat is therefore much greater than that dealt with at Miégebat or Artouste, and the sections of the tunnels are correspondingly increased lower down to carry the extra flow. The maximum flows are 148, 423 and 628 cubic feet per second, respectively, for the three stations.

In all three cases the head tunnels run a short distance inside the rock walls of the valleys, the total length of the tunnels being over 13½ miles. If the formation is of reasonably sound rock, this construction has considerable advantages, as it avoids troubles from avalanches, snow and ice, and other sources of danger to open channels. By the construction of short cross headings, the tunnel can be attacked from a number of points, and the length of tip of the rock reduced in proportion to the number of working faces. In the construction of the Midi Company's works, electric power was transmitted up the valley by means of an overhead high-tension line, supplied by an existing power station belonging to the company in a neighbouring valley, and at a number of points transformers and air compressors were arranged in wooden huts, so that rock drills could be kept going at a number of faces.

The upper station is designed for a capacity of 30,000 horse-power, the intermediate for 50,000 horse-power, and the lower for 50,000 horse-power. The three stations are intended to assist one another. When the mountain snow is melting, the two lower stations will operate alone. The top station, supplied from the reserves of water in Lake Artouste, is only to be operated when the water drawn mainly from the side valleys is not sufficient to give the continuous supply of power required, which is in the neighbourhood of 37,000 kilowatts.

The head-water tunnels for the supply of the two lower stations operate under pressure, so that apart from the loss of head through friction, the head of water from the sluices at the upstream end of the reservoirs leading into the tunnels is utilised in each case. The nature of the ground and rocks at the top

end of the valley made it inadvisable to operate under pressure the tunnel for the supply of the Artouste station. In this case the water is drawn from below the normal level of the lake, and passing through a pressure-relieving chamber, flows into the tunnel, which is about 9300 yards long, with a section of about 6ft. 3in. by about 5ft. 8in., with a fall of one in 83¼. The tunnel passes along the side of the valley and at the lower end goes under a ridge beyond which the water is discharged into a small regulating reservoir of about 176,580 cubic feet capacity. There are three pressure pipes, each 2ft. 7½in. internal

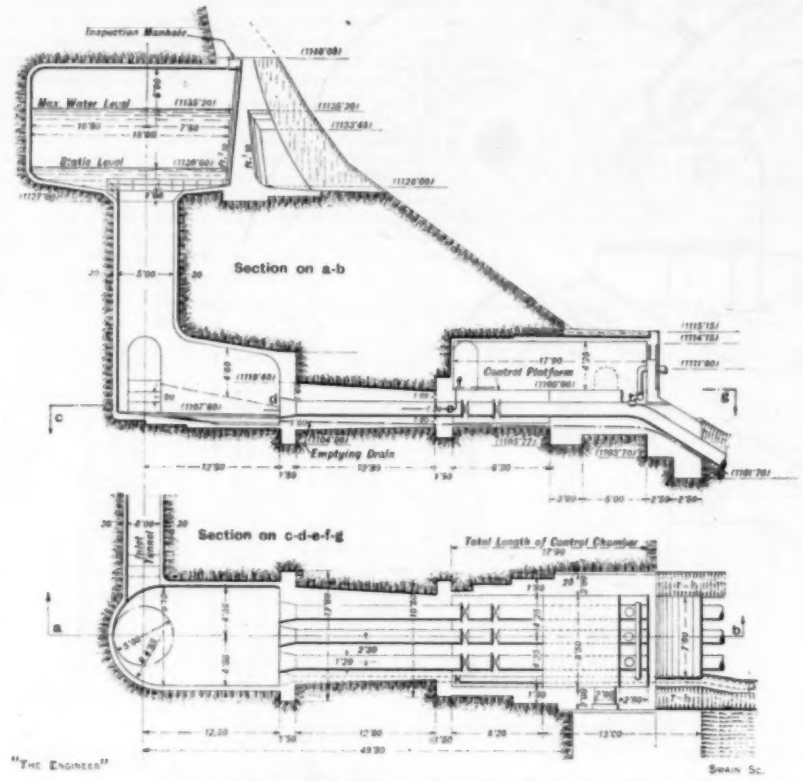


FIG. 3—BALANCING CHAMBER AND CONTROL ARRANGEMENTS

diameter, at the top reduced to 1ft. 11¼in. at the lower end. The power station will contain three Pelton wheels, each of 10,000 horse-power capacity at 500 revolutions per minute, driving 8000-kilovolt-ampère alternators, with two turbines for driving auxiliaries, each of 350 horse-power.

The tail water, reinforced by supplies from two valleys having a combined area of about 35 square miles, flows successively into two reservoirs of a combined capacity of about 4,750,000 cubic feet, and then assisted by the head of water in the reservoirs

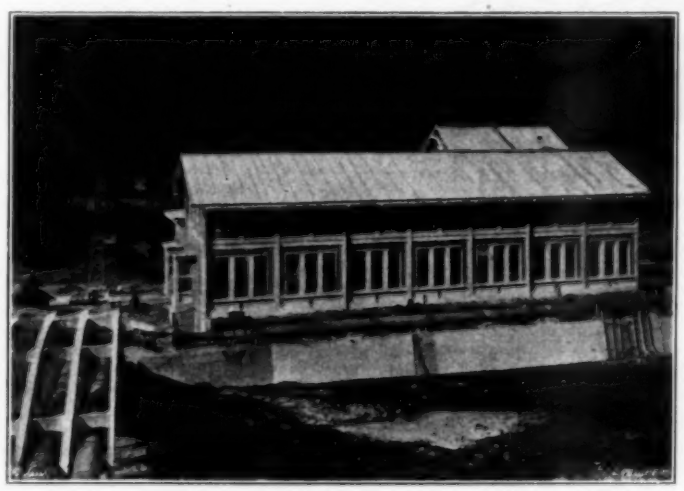


FIG. 4—THE MIEGEBAT POWER STATION UNDER CONSTRUCTION

it flows into a head tunnel, 8369 yards long, with a fall of one in 100 and a section of 86 square feet. This tunnel follows the side of the valley, making a loop round a spur and enters a balancing chamber—Fig. 3—excavated out of the rock and lined with concrete. The arrangement comprises a chamber provided with a vertical shaft about 47ft. high, opening out into an expansion chamber of sufficient capacity and height to allow not merely for the maximum static head, but also for a 17ft. rise in the water level, which might follow a sudden decrease in the load at a time when the water in the tunnel was running at the full load velocity. Access to the balancing chamber can be obtained after it has been emptied by means of a draw-off pipe, by way of a trap and steel ladders. From the chamber the water flows through three pipes, about 3ft. 11in. in diameter, laid in concrete and through electrically controlled head valves, to the pressure pipes, the total static fall of which is 1314ft. Fig. 6 shows the pipe lines with the cableway used to erect them, and for the transport materials generally. Fig. 4 shows the Miègebat power-house under construction. Venturi meters of the Kent type are fitted to the pressure pipes for the measurement of the water flow. The power station building is made of reinforced concrete.

DOUBLE-JET TURBINES.

At the Miègebat station there are five Pelton wheels, each of 10,000 horse-power at 500 revolutions per minute, and driving 7000-kilowatt alternators. Fig. 5 shows one of the turbines in the shops of the makers, Les Constructions Electriques de France, of Tarbes, which built the turbines and alternators for all three stations. Fig. 7 and 8 show sections of the turbines. The buckets, it will be seen, are fastened to the wheel by means of clamping rings, with through bolts that act as keys. There are two jets, each provided with a needle valve and deflector. A casing of steel plate is arranged beneath the wheel to prevent the erosion of the concrete foundations.

The governor gear is of the type originally developed by Monsieur Singrun, of Epinal, in the French Vosges. With Pelton wheels of large capacity or operating under a high head, it was found that the sudden cutting off of the water by means of a needle valve might lead to heavy shocks on the pipe line. One method of minimising such shocks is to arrange the jet on a flexible joint, so that it can be diverted from the wheel in the case of a very sudden decrease in the load. An alternative method is to throw into the jet a deflector which will hold the bulk of the water off the buckets until the needle valve has had time to operate slowly, the deflector receding as the needle advances. If the load falls off gradually the deflector does not come into action. If the load is mainly of the traction kind, involving the possibility of several heavy trains switching off current simultaneously, governing gear of this kind is very suitable.

In the Singrun arrangement—see Fig. 9—two governor gears are placed side by side. One controls the needle and the other the jet, and both are operated

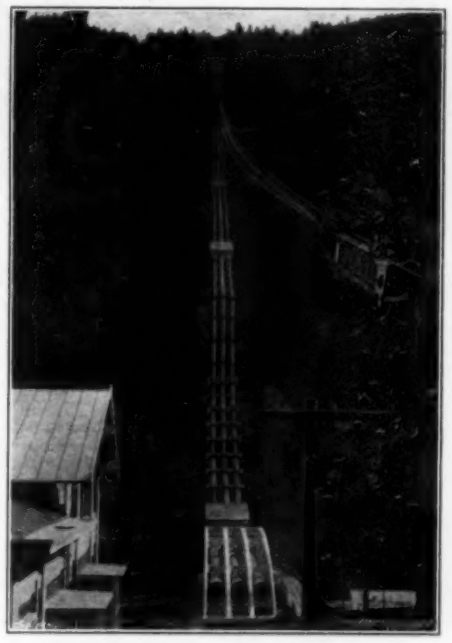


FIG. 6—PIPE LINE AND CABLEWAY

by the same set of governor balls, which affect two sets of double floating levers. Both sets of gear are of the same general type, and are placed in a common oil tank. Two pistons in two single-acting cylinders form the servo-motor for each duty. One of the pistons operating the deflector has a spring behind it which holds the deflector partly in front of the needle when the turbine is shut down.

Oil is supplied under pressure to both servo-motors by a gear wheel pump, in circuit with a large air vessel. When the load is steady a spring-controlled by-pass valve returns the oil to the tank. The main distribution valve is operated by the pressure of the oil against a spring. By means of cams and floating levers the correct sequence of movement is obtained. As the needle advances to take up the duty the right-

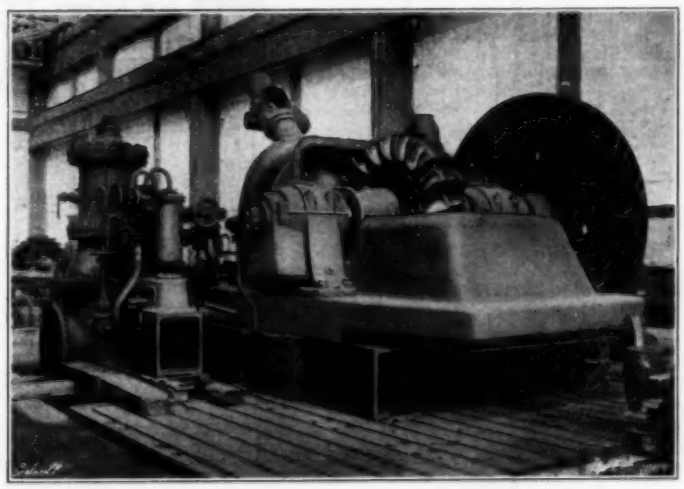


FIG. 5—10,000 H.P. PELTON WHEEL IN MAKERS' WORKS

hand cam is pushed forward and operates the distribution valve, which moves the deflector out of the jet. Arrangements are provided, which, should the governor belt break or the oil pressure fail, cause both the needle valve and the deflector to operate and cut off the water from the turbine. As usual with servo-motor governing in power stations, the speed can be regulated and the plant shut down from the main switchboard.

A heavy fly-wheel, about 10 tons in weight and about 10ft. 2in. in diameter, is placed between the turbine and generator. It is of cast steel with a forged

MIDI RAILWAY OF FRANCE—MIEGEBAT POWER STATION

LES CONSTRUCTIONS ELECTRIQUES DE FRANCE, TARBES, ENGINEERS

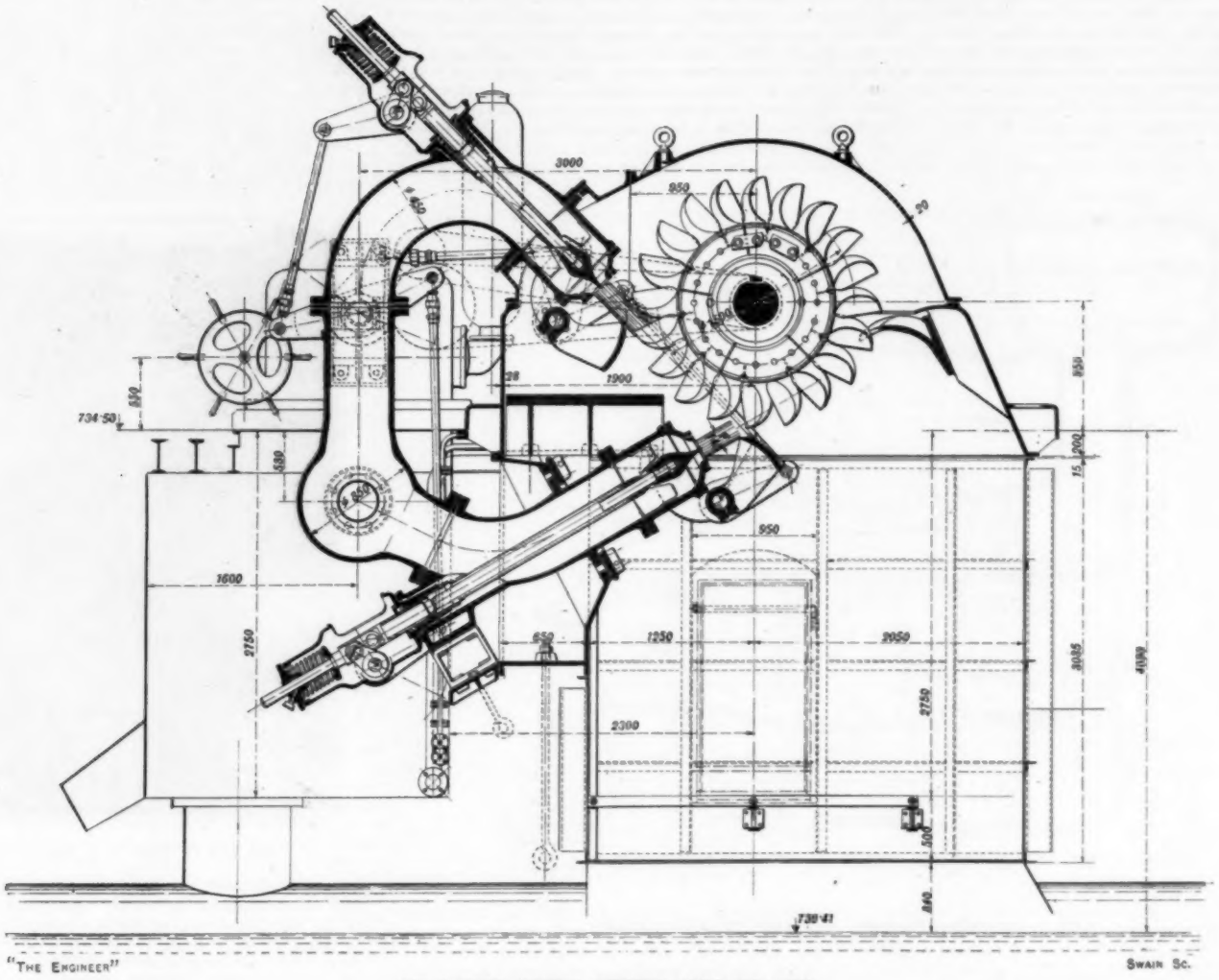


FIG 7—CROSS SECTION THROUGH 10.000 H.P. UNIT

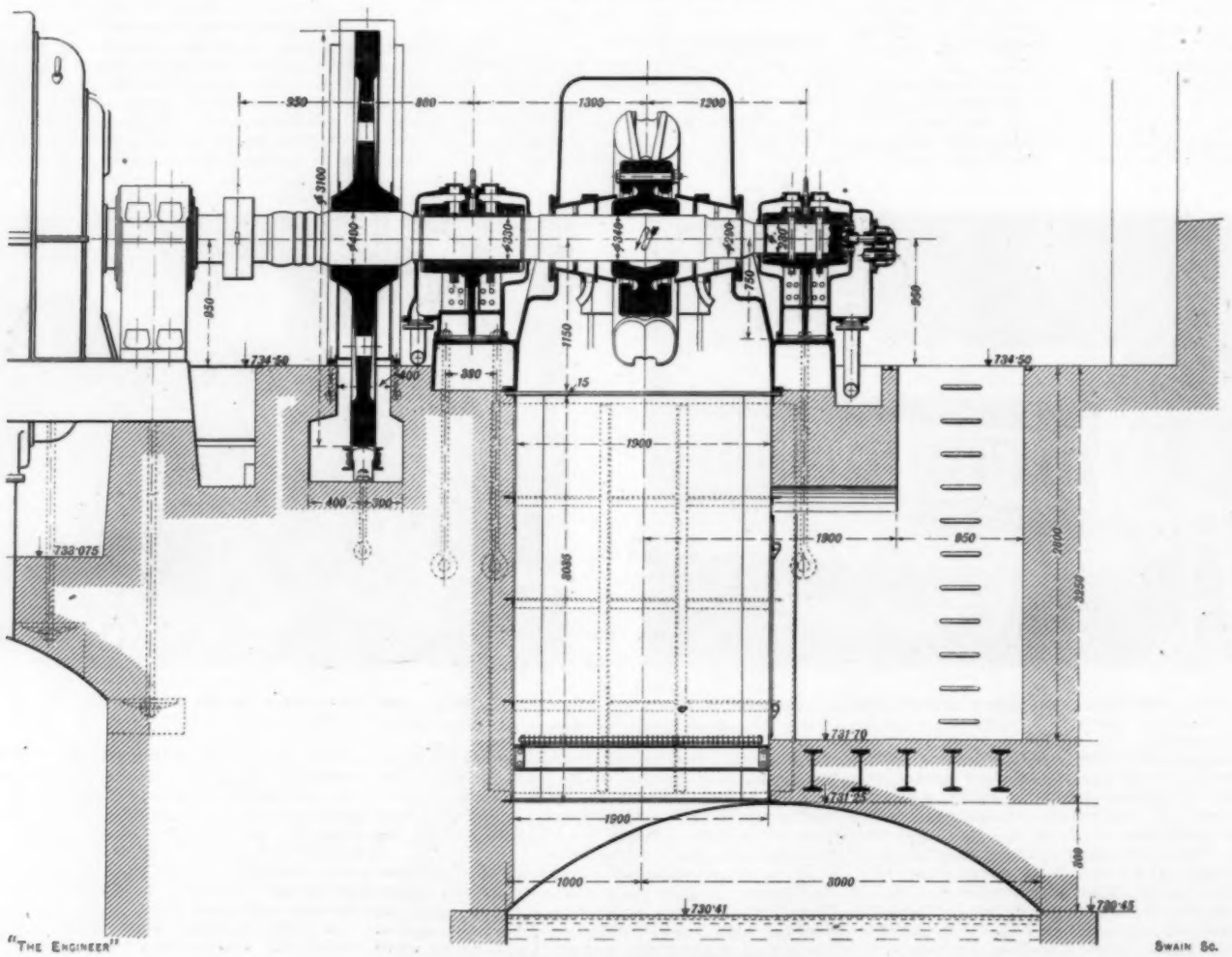


FIG. 8—LONGITUDINAL SECTION THROUGH UNIT

steel outer ring shrunk on, and is designed to withstand a speed of 900 revolutions per minute. The fly-wheel is housed in a sheet steel casing, and a brake is provided underneath it to facilitate rapid shutting down should it be required.

The generator is of the enclosed type, and is designed on lines originally developed in connection with steam turbine practice. It has many features in common with generators designed and made in England by the English Electric Company, with which concern Les Constructions Electriques de France has a working alliance. The main bearings of both turbine and alternator are fitted with oil rings, and oil circulation under pressure is obtained from a toothed wheel pump placed at the turbine end of the main shaft. The bearings themselves are of the Michell type. The generator is of the three-phase type, and has an output of 8000 kilovolt-ampères at 500 revolutions per minute, with a power factor of 0·875. It is wound for 50 periods and 10,000 volts. The windings are star-connected, the neutral point being earthed. The six ends of the three windings are fitted with transformers for the operation of the relays of the automatic main generator switches. Six thermo-couples are arranged in the stator at convenient points for the measurement of the temperature. The efficiency of the alternators is 96 per cent. at full load, 95 per cent. at three-quarter, and 93 per cent. at half load. The alternator weighs 72 tons, the rotor accounting for 33 tons. Forced ventilation is given by a fan at each end of the rotor, which fans draw fresh air from outside by means of special passages in the foundations. The air can be discharged either outside or into the turbine house for heating purposes in winter.

At the Miègebat station there are two auxiliary Pelton wheels of 500 horse-power each at 900 revolutions per minute. These wheels each drive in tandem a 250-kilowatt exciter generator at 120 volts and a direct-current generator of 60 kilowatts, 120 volts, the latter being used for various power station services.

The generators for the three power stations are of the same type, speed and output, the electrical lay-out in each case being very similar.

The Hourat Station.

The water from the tail-race of the Miègebat station passes direct into a reservoir of about 2,650,000 cubic feet. A further supply of water from a catchment area of 19 square miles flows into the same reservoir. Special arrangements are made by means of water-cleaned racks to prevent the entrance of leaves into the tunnel, the lower slopes of much of the catchment area being covered with trees.

The pressure tunnel has an area of about 131 square feet, the comparatively large section of this and the tunnel higher up being designed to aid the regulating reservoirs in their duties. The tunnel between the two lower stations is about 3½ miles long, and terminates in a balancing chamber of a similar type to that shown in Fig. 3. The total head is about 700ft. In the Hourat station there are five turbines of the Francis type, each of 10,000 horse-power at 500 revolutions per minute, with two auxiliary turbines of 500 horse-power each.

The current at each station is stepped up from 10,000 to 60,000 volts, and passed to a main outdoor transformer and switching station at Hourat by two high-tension lines. That portion of the current which is not required for local purposes at either 60,000 or 10,000 volts is raised to 150,000 volts for transmission to main step-down stations at Pau, Dax, Tarbes, Toulouse, Bordeaux, &c. Current is supplied along the lines at 10,000 volts for the lighting of stations and for some local supply systems.

The total continuous power supplied from this group of stations will be in the region of 37,000 kilowatts, and at certain times of the year the continuous output will reach 57,000 kilowatts. At all times, thanks to the existence of the small reservoirs above the two lower stations, peak loads of 60,000 kilowatts will be comfortably handled.

One factor which influenced the original decision to electrify the section of the Midi Railway between Bordeaux and the Spanish frontier was the heavy claims for damages resulting from fires in the "Landes" reclamation forest area, which fires were often unjustly alleged to have been caused by steam locomotives. The cessation of such claims which will result from the electrification scheme will form a material item in the economy resulting from the change.

We have to express our thanks to the engineer-in-chief of the hydro-electric branch of the Midi Railway and to Les Constructions Electriques de France for information, plans and photographs used in the preparation of this article.

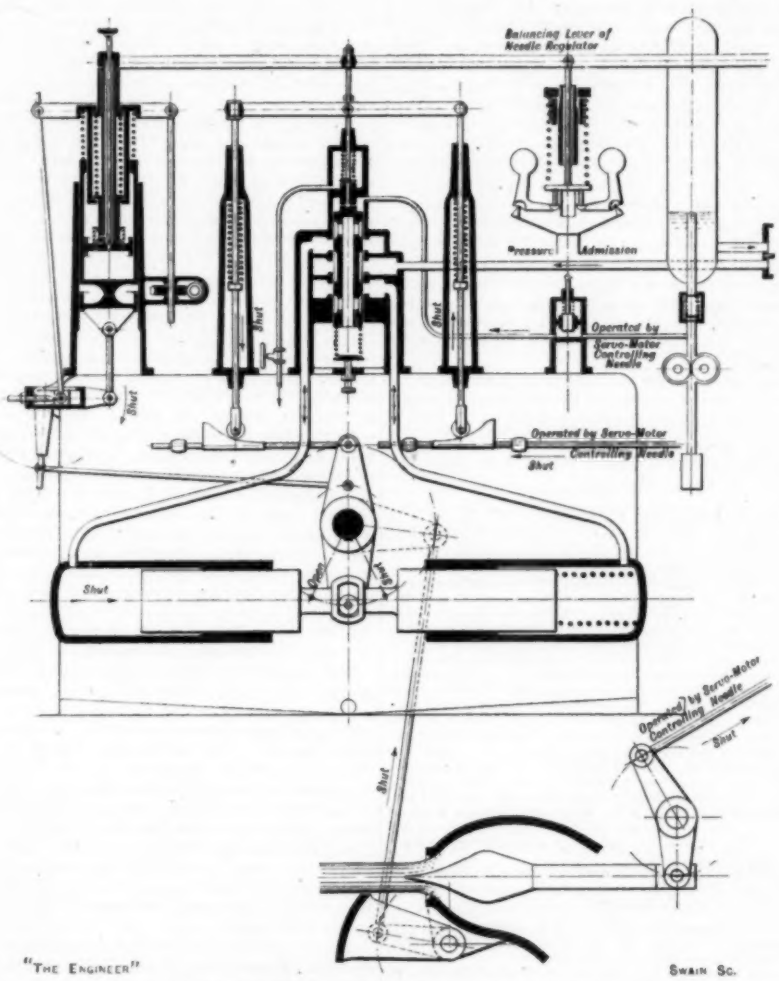


FIG. 9—THE SINGRUN PELTON WHEEL CONTROL GEAR

The durability and protective power of aluminium paint is, according to Mr. E. Andrews, probably due to the complete opacity and high reflectivity of aluminium, which reflects from 65 to 70 per cent. of the visible spectrum, and approximately 90 per cent. of the infra-red. Aluminium paint has a great affinity for iron and steel, but in order to obtain the best results, it is particularly desirable for the paint to be applied to the metal surfaces somewhat sparingly. Recent exposure tests on iron and steel panels painted with aluminium paint, show that the paint, when properly made and applied, is capable of protecting iron and steel under relatively severe conditions for about three years, with a satisfactory prospect of longer life.

Institution of Naval Architects.

No. II.*

Members reassembled at the Royal Society of Arts on March 25th, when the Duke of Northumberland again occupied the chair.

A paper on "Temperature Variation and Heat Stresses in Diesel Engines" was presented in person by Mr. Robert Sulzer, who had made the journey from Switzerland to be present. We begin to reprint it practically in full on page 391.

Professor W. E. Dalby said that Mr. Sulzer had made a valuable contribution to the literature of internal combustion. The whole progress, maintenance and design of internal combustion engines depended on knowledge of the heat gradients, and it was interesting, in that connection, to recall the measurements of Professor Callendar on the steam engine. A generation ago engineers were brought up to think that the wall of a steam engine cylinder followed the temperature of the steam, but Professor Callender scotched that idea, and for the first time substituted facts. Mr. Sulzer's work was comparable with that of Professor Callendar. The temperatures given corresponded with the variation on Professor Callendar's surface. The most valuable part of the paper was the information concerning the heat gradients which led to knowledge of what the stresses were. The brief summary of the author's experiences which appeared in one part of the paper would be very valuable to engine designers.

Engineer Vice-Admiral Sir Robert Dixon regarded the paper as of very great interest to those designing or building Diesel engines, and he had no doubt that designers of types of engines other than the Sulzer would try to adapt some of the results of that paper. It would be of interest if Mr. Sulzer could give some information as to the surface temperature rather than the temperature at the point close to the wall which he had taken. Although he noticed that it was stated in the paper that records were taken of the temperature no figures were given, and he wondered if Mr. Sulzer would supply that information, as it would be of great value. There was a reference also to the temperature of the piston rings which was interesting because it was shown that the temperature of the piston rings was very moderate. That observation was to some extent borne out by the results which had been obtained with a two-cycle double-acting engine running at high speed, with which, although there had been troubles, there were none with the piston rings.

Engineer-Commander Hawkes said that Mr. Sulzer had emphasised the simplicity of construction and urged that the walls of the cover should be as thin as possible. Years ago he (the speaker) had advocated that course, but it did not meet with any great response at that time. There was a general impression that thickness meant strength, but frequently thickness meant weakness rather than strength, and he thought that truth was being realised more now than it was before the war. A few years ago he put forward the proposal that the covers should be made in two parts, the inner being the one in contact with the working fluid, and that it should be as thin as possible, while the outer might be of reinforced metal. They would together form a channel for the passage of water. The object was to have as simple a cover as possible, and at the same time to reduce the stresses. Simplicity was absolutely essential to success in things of that kind. At the present time a certain amount of attention was being paid to temperature stresses, but in many cases very little attention was given to the cooling parts. Having had experience some years ago in connection with piston rings, he knew the difficulties, and could therefore fully agree with Mr. Sulzer that rings needed great attention. In 1924, before the meeting of the North-East Coast Institution, he indicated that the usual mathematical method of treatment of temperature stresses might show something small, but that those small oscillations might play an important part in causing fractures. He noticed that the author referred to the fact that the stress in cast steel would be twice as much as in cast iron. That was a point which he always realised. They would all like to have further information as to the temperature in the combustion space; it was not a constant, but a varying temperature. It would certainly be useful to have information as to the distribution of the temperature throughout the combustion space at the dead centre just after combustion.

Mr. Ruck-Keene commented upon the extraordinary delicacy of the instruments and apparatus used for the purpose of measuring the temperatures in the various parts of the cylinder cover, liner and piston. Those members who were daily associated with work in the laboratory were better able to discuss the degree of accuracy which the apparatus might be reasonably expected to possess, but as a result obtained from a workshop test, it appeared to be a wonderful performance to be able to record the change in temperature of a piston ring when passing over a lubrication hole or even a row of lubrication holes. It appeared that the piston rings of a two-cycle Diesel engine worked under more favourable circum-

* No. I. appeared March 26th.

stances, as far as temperature was concerned, than those of steam engines fitted with jackets, but he would ask whether the difficulties appertaining to lubrication of the pistons were not generally recognised as being less in the case of steam engines than in Diesel engines. It would be granted that, in general, considerably more lubricating oil was used in cylinders of Diesel engines than in equivalent steam reciprocating engines, and the wear of the piston rings was more rapid than in steam engines. That might be due to the high rubbing pressure of the rings when working under an initial gas pressure of 500 lb., as compared with about 200 lb. per square inch in the case of steam reciprocating engines. Possibly the author's intention was only to remove the impression that high temperature was the chief reason for the high consumption of lubricating oil which had been found necessary in Diesel engine practice. Referring to an interesting point shown by one of the figures, he remarked that, if he read the diagram correctly, it appeared that on starting up from cold the temperature of the cover might rise to, roughly, about 165 deg. Cent. in two minutes. That was a somewhat rapid rise in temperature for a casting to withstand, and it occurred to him that possibly some of the failures which had taken place in covers might have originated in small flaws resulting from starting conditions, and it might be that an initial warming up of the engine, such as was usual in the case of at least one type of Diesel engine, might reduce the possibility of failures of that kind.

Engineer-Commander Tostevin referred to the public spirit shown by the willingness of the experimenters to allow their work to be published generally for the benefit of others. The results which had been given applied, of course, only to a particular engine and a particular type, but it did suggest conditions that obtained in other classes of engines. Many were rather astonished to find that it had been possible to take those observations and to measure the temperatures so accurately. The fact that the highest temperature recorded was that of the upper part of the cylinder liner might have been anticipated because the metal was much thicker at that point. It was possible, as Commander Hawkes had shown, to reduce the stresses in the cover by reducing the main portion of the cover and shielding with a thin cooled plate. Admittedly, if that were feasible it was an extra complication. As regarded the temperature of the piston rings that was most interesting, and he was surprised to find that the temperature of the rings was so moderate. In the design of the piston mentioned the ring was made fairly thin, and the whole of the ring-carrying portion was cooled. It would have been interesting to know whether the moderate temperature of the piston ring was due to the care taken in the cooling or whether the liner had some predominating influence.

Mr. Le Mesurier said that hitherto it had not been uncommon to make comparisons of different engine ratings by giving separate figures showing fuel burnt per unit area of the parts in the combustion chamber, and, among other things, Mr. Sulzer's paper would serve the very useful purpose of putting an end to that old unscientific and very misleading method of rating a Diesel engine. Accurate calculations of temperatures of the various parts were of inestimable value for design purposes, at least for designs where calculations could be made ; but, of course, for engines which were actually built and in service there could be no better criterion for judging their rating than observing a record of their performances. If their heat stresses had not been properly allowed for failure was bound to occur sooner or later. With regard to the superimposed heat stresses caused by the fluctuation of temperature, he thought it would be of great interest if Mr. Sulzer could say whether those stresses were of greater significance as the cylinder dimensions increased. The figures had only been given for an engine of a certain size. There was also the question whether they were likely to be more important in a four-cycle engine than in a two-cycle engine. He had experience of the trials of an engine which happened to be the same exactly as that on which those tests were carried out. For a period of about four hours runs were carried out over the measured mile, and the indicated mean pressure in the cylinders was about 120 lb. to the square inch, and in one of the cylinders, owing to the engine not being exactly balanced, it reached 9 atmospheres.

Wing Commander Cave-Brown-Cave asked whether any experiments had been carried out at higher or lower temperatures, and was boiling water used in the jackets. He explained that he raised that point because of some very interesting tests which had been carried out by Professor Gibson with an aero-engine, which showed that as soon as the water boiled the temperature became far more uniform, the temperature of the hottest part of the cylinder was reduced and that of the other parts increased so that there was a smaller variation of temperature throughout the cylinder block. Although, with the exception of Professor Gibson's, no exact experiments had been made, it was a fact that there was no sign of overheating in any of the engines, and the system appeared to be quite satisfactory.

Mr. Sulzer, replying to the discussion, said he had been asked so many questions that he thought it would be difficult to go into detail with regard to them all at the moment, but he would be pleased to reply to them in writing. With regard to the theoretical side of the paper and the curves, further reference might be made to a paper which had already been published by Dr. G. Eichelberg,* who had carried out the tests and to whom he was indebted in the preparation of the present paper. Concerning the remarks of Sir Robert Dixon, there was a very slight gap between the skin temperature and the temperature recorded half a millimetre below. The surface temperature curves and the curves at half a millimetre below the surface were, however, essentially of the same character as the curve of heat flow itself. The suggestion of Commander Hawkes to use thin plates was very interesting. His firm had carried out some designs in a similar way, but it had found some difficulties in supporting the thin parts. It had had some not very favourable experiences in some designs, and had therefore gone back to the compromise of the simple cover of the two-cycle engine, which gave satisfactory results, although he would admit that some of the stresses were rather high. In regard to the remarks which had been made as to the heat flow, he proposed to go into that matter later, and he hoped to give satisfaction to inquirers. In reference to the remarks of Mr. Ruck-Keene on lubrication, he thought it was true that from the point of view of the effect on the rubbing faces the conditions in a Diesel engine were more favourable than in a steam engine with high superheat. Concerning the remarks of Commander Tostevin as to the stresses on the upper part of the liner, those stresses were only present when the engine was running full load ; when the engine was running light the whole process of combustion took place in the centre part of the combustion space. Actual measurements of the temperature indicated that the heat in the liner only reached the temperature of 338 deg.-Cent. when the engine was running full load. Comparisons had been made between the cooled top and the non-cooled liner, and the effect of the cooling had been favourable to stresses in some respects, but he preferred to have the compromise of having the bottom of the liner cooled rather than having a cooling space of comparatively small dimensions, which was likely to get choked with water. In reply to Commander Cave-Brown-Cave, no measurements had been made with boiling water in the jackets.

The Chairman said that the discussion accorded to the paper had been a reward to Mr. Sulzer for having come all the way from Switzerland to deliver it.

Mr. W. J. Lovett read a paper on "Comparative Freight Economics of a Cargo Vessel with Reciprocating and with Diesel Machinery."

COMPARATIVE FREIGHT ECONOMICS OF A CARGO VESSEL WITH RECIPROCATING AND WITH DIESEL MACHINERY.

In this paper an attempt is made by comparative analysis to arrive at the most economic conditions of trading for a cargo vessel of 8000 tons gross deadweight. The basis vessel is 400ft. long and 53ft. broad with a draught of 23ft. 6in. and a block coefficient of 0·775. The power assumed is 2400 indicated horse-power or its equivalent, capable of giving the loaded vessel a maximum speed of 11 knots, but the ordinary service speed is under 10 knots with a reduced power. The reciprocating machinery consists of triple-expansion engines with three natural draught boilers coal fired. The alternative equivalent Diesel machinery has steam auxiliaries.

Comparisons are made for one year's trading under the following divisions :—(A) Total weight of cargo carried ; (B) annual expenditure ; (C) freight rates ; (D) profit and loss. In each case the effect of various modifications is shown, comprising :—(1) Fuel prices ranging from 15s. to 25s. for coal and from 30s. to 70s. for oil ; (2) voyages ranging from 2000 to 8000 miles ; (3) speeds ranging from 8 to 11 knots ; (4) steamer *versus* motor ship ; (5) loading conditions with full cargoes both ways, also with full cargoes only one way.

It is not claimed that the assumptions and costs agree with practice, but their comparative value may be admitted.

The following is a summary of the results obtained :—

(1) The tremendous cost of stevedoring for vessels on short voyages makes the design of the loading and discharging appliances and facilities of paramount importance.

(2) It would appear to pay large shipowning companies to carry some or all of their insurance.

(3) The equivalent proportionate costs of coal and oil are such that a change of 1s. in coal prices requires a change of about 3s. in oil prices, but low price of coal is of more value to the steamer owner than constant relationship between coal and oil prices.

(4) It costs very much less to run a vessel on long voyages than on short voyages.

(5) Within small limits an increase of speed is not costly as affecting transport rate.

(6) It is not much more costly to run a vessel with full cargoes out and home than with full cargoes home and ballast only outward.

(7) There is an economical speed for all lengths of voyages, and this is not necessarily the slowest speed. This speed is higher in the motor ship than in the steamer.

(8) For very full vessels a reduction in the block coefficient will probably result in a cheapening of the cost of transport.

(9) The motor ship is more economical than the steamer for long runs and higher speeds, and the economy is greater when full cargoes are not obtainable ; but with coal available at 15s. per ton the steamer is at present more economical than the motor ship when trading on short runs from the United Kingdom.

(10) Under certain conditions of trading, when a vessel has to go out in ballast to get a homewards cargo, the tramp steamer, with coal bunkers full and with ballast tanks full, will be at a deeper draught and more seaworthy with empty holds than the Diesel-engined vessel in similar circumstances. This might be a deciding factor of the design.

Sir John Biles said that all would recognise the importance of the subject raised in that contribution. It reminded him that he had ventured at the Liverpool meeting to suggest that a Chair of Shipping Research should be endowed there or at another university to deal with such problems as were discussed in Mr. Lovett's paper. The science of shipping statistics ought to be covered at one of the universities. He had dealt last year with a subject somewhat similar to that raised in the paper. Mr. Lovett approached it by way of freight rates, whereas he had done it by assuming freights, assuming coal, and assuming freight rates, coal costs and oil costs, and other things which had to be calculated and then determined the length of voyage in which the Diesel and the steamship would give equal commercial efficiency. He thought that led one to definite results in special cases. Taking, say, a 12-knot cargo vessel with an engine power of 3600 and running, say, 250 days per annum with Diesel oil at £4 a ton fuel, oil at 65s. a ton, and with coal at 23s. a ton, with the Diesel vessel consuming ·42 lb. per shaft horse-power, they got out a definite comparison in terms of the distance that could be steamed for the same commercial efficiency ; that was the same dividend on the money invested. With those conditions the vessel could steam 10,800 miles on coal and in the case of the oil-fired ship the distance would be 6120 miles. At greater distances the Diesel ship was shown to be superior, and below the coal vessel was better. That was the result of a direct calculation. Mr. Lovett obtained the same results from his diagrams. The number of days steaming per year could be varied and the rate of fuel oil used in a Diesel engine per shaft horse-power could be varied with different results. He (Sir John Biles) had made some other comparisons. He took a turbine steamer having a power plant of from 11,000 to 12,000 horse-power, fitted with Scotch boilers working at 200 lb. pressure. The first question that arose was as to the horse-power of Diesel machinery which could be got in for the same weight as the turbine and Scotch boiler arrangement. The answer was 8750 horse-power, as against 12,000 horse-power ; the allowance was made for the lighter fuel. Making a comparison on the basis of space occupied per shaft horse-power with high-pressure turbines it was 143, against 125 for the low-pressure turbine with water-tube boilers, and 104 for the Diesel engines. On a purely personal matter he would like to say that he had been accused of holding a brief for the high-pressure turbine ; he wanted to say that while the Diesel engine was in some fields unrivalled, for other applications the high-pressure turbine was to be preferred. Having said that there were applications for both, he did not think he could be accused of holding a brief for one or the other. By the next annual meeting they might be a stage further on in regard to that question, as the results of trials of the new high-pressure turbine ship should be available.

Mr. Andrew Hamilton pointed out that the number of days spent in port and at sea were not mentioned. Twenty days had been suggested for the stay in port, but that was an under-estimate. In any ships with which he was connected ships could not manage more than about 200 days per year at sea. He noticed also that apparently no allowance was made for interest on capital, and that was a question of importance. It would be interesting if some statement could be made as to the difference between the compound, the triple-expansion engine, and the single reduction turbine. The question of prices of fuel at different ports was also one of great importance, particularly when notice was taken of the great fluctuations with regard to oil. It was possible to begin the voyage with oil at 65s. a ton, and at Panama Canal ports it might be at 43s., and in the Californian area oil might be as low as 30s. They had to compare those prices with the price of coal. An omission of some importance in the information contained in the paper was in regard to capital cost of the oil engine ship. That figure was necessary if correct deductions were to be made.

Dr. A. Robb dealt with the relative prices of coal and oil. He said that recently published information showed them to be 23s. per ton for coal and 62s. for oil, and he assumed that the oil bought at that price was boiler oil. Some superintendent engineers regarded the use of boiler oil as an extravagance, having regard to the fact that a process of mechanical separation was required. The subject of low speeds had been raised in the paper, but to run a big engine at low power was doubtful economy ; if, on the other hand, Mr. Lovett had taken the smaller engine for the low speed, the figures would have shown up rather better, because with the smaller engine a slightly increased quantity of cargo could be carried. He was surprised at the statement that the Diesel engine ship showed up to advantage in periods of depressed trade, but in any event it could be claimed that in normal times the steamship possessed an advantage from the owner's point of view.

Mr. W. V. Cleghorn pointed out that neither the first cost, fuel consumptions per horse-power, nor times taken to turn round for the respective vessels were stated, nor were they easily deduced from the information given. Yet those were the factors which governed the whole problem. During the past few years much had been done to improve the efficiency of reciprocating machinery, the most promising lines of advance being a rise in steam pressure to over 250 lb. in Scotch boilers, pre-heating of air and the adoption of poppet valves. Each of those developments had been associated with a reduction in coal consumption down to 1·2 lb. per shaft horse-power hour. He had had personal experience of a Lentz poppet valve engine which, after three years' service,

* Temperaturverlauf und Wärmespannung in Verbrennungsmotoren. V.D.I. Forschungsarbeiten, No. 263, Berlin, 1923.

showed a coal consumption below that figure. On the other hand, the reports of the Marine Oil Engine Trials Committee did not confirm the remarkably low consumption of oil engines frequently mentioned in the Press. He hoped that advantage would be taken of the present opportunity to obtain the real fuel consumption obtained with the latest type of machinery.

Mr. Lovett, in his reply, said Sir John Biles had referred to the high efficiency steam engine, but it must be remembered that the Diesel was in its infancy and was going to develop. He thought the same could even now be said of the steam engine, except that it was not going to develop quite as much; at any rate, there was not quite as much room for development in the steam engine as in the Diesel. Referring to the question of the days in port, he said ten days were allowed for loading, and, in addition, in the case of the Diesel, there would be twenty-one days in dock for purposes of overhaul. As to the cost of oil which had been assumed, he knew ports where Diesel oil was much cheaper than coal. The office expenses he quoted were based on the percentage of first cost plus the rate per 100 tons carried.

At the afternoon meeting on March 25th Professor C. M. Carter read a paper on "Propeller Dimension Formulæ Based on Mr. R. E. Froude's Model Screw Experiments."

PROPELLER DIMENSION FORMULÆ BASED ON MR. R. E. FROUDE'S MODEL SCREW EXPERIMENTS.

To those who are accustomed to Froude's $C_s C_o$ curves and making the calculations involved, the production of a new set of screw dimension curves satisfying definite ship design conditions does not present any difficulty. The time required, however, is such that it appears advantageous to employ, if possible, a simpler method based on Froude's curves which will give the required information with less labour and in less time, provided that the accuracy of the results is sufficient for at least the preliminary design stage. In this paper the author gives particulars of certain formulæ which he has deduced from Mr. Froude's curves, and which he hopes will be of assistance to designers in the early stages of a ship design, when it is still possible to make changes in the tentative arrangements—such as the proposed screw revolutions and form of ship in wake of screw positions—so as to obtain as high a degree of propulsive efficiency as possible. The method by which the arithmetical formulæ have been deduced is described and curves are given. In three appendices the applications of the formulæ to determine screw dimensions to satisfy definite ship conditions, the effect of different rates of revolution and the calculation of optimum efficiency for given ship conditions are set forth. The results which are obtained appear to be close enough, compared with those derived directly from Mr. Froude's curves, to satisfy most requirements.

Mr. W. H. Berry said that each designer had his own method of attacking the problem of propeller dimensions, pitches, and efficiency. Professor Carter had worked out simple formulæ which, he hoped, would make the task easier and save a good deal of time. At the Admiralty Froude's results had been very carefully tabulated in a variety of ways, but that information was not generally available, and for ordinary practice the method suggested in the paper ought to prove of great assistance.

Mr. M. P. Payne reminded the meeting that shortly before he retired Mr. Froude himself devised a simpler method of presenting his results with a somewhat similar object to that which Professor Carter had in mind. The method outlined in the paper was an arithmetical process, whereas Mr. Froude had proceeded on more graphical lines. A chart was prepared consisting of a series of efficiency curves to a base which was proportional to the diameter of screw for any particular ship, each efficiency curve being appropriate for that ship to one value of the revolutions of the screw. The envelope of that series of efficiency curves determined the maximum efficiency possible for any given diameter. An auxiliary curve drawn on the same base as the efficiency curve gave the revolutions necessary to obtain the maximum efficiency. A few cases had been worked out on Professor Carter's method and the screw dimension curves obtained compared with those derived in the usual manner from the original curves of Froude. The error in efficiency was never greater than 1 per cent., but the pitch was not obtained quite so accurately. It was possible, he thought, by slightly altering the constants to make the formulæ for the curves obtained from Froude's data more closely for values of C_s between ·025 and ·2 and obtain more accurate results.

Sir James Henderson said the paper dealt with the particular problem discussed from the point of view of the designer, but it was also necessary to look at the question with the object of advancing the theory of propulsion. Practice had outstripped theory and a new discovery was needed. That discovery lay hidden in the curves of Froude. The science of the subject was in what Kelvin would have called the natural history stage and should be carried into the natural philosophy stage and brought into accordance with the laws of dynamics.

Mr. G. S. Baker referred to various attempts which had been made to rearrange Froude's experimental data with the object of simplifying the calculation required in designing screws of a given ship. Froude had himself stated that it was not practicable to treat pitch ratio as an unknown quantity, and many endeavours had been made to overcome that difficulty. No method with which he was acquainted came so near a real solution as that suggested by Professor Carter. By using a very simple co-relation of pitch ratio and slip the pitch ratio was disguised and diameter calculated direct in one step and the pitch derived in the second. The author was to be congratulated on the simplicity and usefulness of the method he had worked out.

Mr. R. W. L. Gawn pointed out that once speed, make, hull efficiency, and thrust horse-power had been satisfactorily estimated in the design stage the routine process of obtaining screw dimensions was a fairly easy task. The real achievement of Professor Carter consisted in condensing a large part of Mr. Froude's propeller results, but he hardly accepted the method suggested of ascertaining the revolutions as likely to give the desired results. The formulæ were not perhaps sufficiently elastic to admit of a satisfactory solution of the problem.

Mr. W. Hamilton Martin gave a brief account of experiments with propellers having two, three, four, and six blades and of two different pitches, 9ft. 6in. and 10ft. 6in. The six-bladed propeller was ultimately fitted as being the best of the series, and in the ship to which it was fitted vibration and cavitation were practically absent. He would like to know whether tank tests or trials had been made on propellers with a higher number of blades than usual, or had it been decided that experiments of this kind would have no value.

Professor T. B. Abell, in a written communication, said he had had an opportunity of testing the method described in the paper and was able to confirm the claim that for preliminary proposals it was quite satisfactory. If Professor Carter would prepare tables for other relations between C_o and C_s it was likely that his method would be extensively used. Those who were already familiar with the Froude method would not, however, be disposed to discard it.

Professor Carter, in reply, said his formulæ were only intended to apply to the data of Mr. Froude. He was interested in Mr. Payne's suggestion, which would receive his attention, as he believed it would prove a useful extension of the work.

Mr. W. G. A. Perring then introduced a paper, entitled "Some Experiments upon the Skin Friction of Smooth Surfaces."

SOME EXPERIMENTS UPON THE SKIN FRICTION OF SMOOTH SURFACES.

In this paper an account is given of some experiments that were conducted at the William Froude Tank upon the skin friction of smooth plane surfaces. It deals with the same general problem as last year's paper on "Form Effects and Form Resistance of Ships." The experiments of Herr Gebers upon water planes at Vienna, and the more recent experiments of Dr. Stanton with a plank in the 4ft. wind channel at Teddington, have pointed to there being a longitudinal edge effect of considerable importance associated with the measured resistances of smooth plane surfaces. The construction of a 28ft. plank at Teddington has enabled an investigation of this edge effect to be made. This model was run at different immersions and speeds, and the resistance of it was compared with the results obtained from four other models of differing length and girth. The experiments cannot be regarded as a complete investigation into the subject of the longitudinal edge-effect plank bodies introduce, but the magnitude of this effect is indicated for the special cases dealt with. When the girth is large the edge-effect is unimportant, when dealing with surfaces of moderate girths the shape of a protruding edge appears to be important, and when the girth is small the edge produces an important influence, because it is then becoming a considerable percentage of the total resistance. It is also very apparent from the tests that similarity of form plays very little part in the specific resistance of a plank, and that the specific resistance of any flat surface of definite smoothness can be calculated from the velocity and length. When the wetted surface is part of a solid body similarity of form is necessary, it having previously been shown that "form" or three-dimensional flow, has an appreciable effect on the frictional resistance. In the second part of the paper the frictional data for smooth surfaces obtained by tank experiments is compared, whilst in the third part of the paper the variation in the specific resistance of long surfaces is discussed. The author expresses his gratitude to Sir Alfred Yarrow, whose assistance has enabled this further work to be undertaken.

Mr. W. H. Berry said the author had dealt with a subject which had been much to the fore during the past few years. In the mercantile marine there was some doubt cast on the extension of the 50ft. plank for the larger ship, and he hoped that that fresh attack on the problem would lead to a more accurate knowledge of the subject.

Mr. G. S. Baker regarded the edge effect as the most salient feature brought out in the paper. It could hardly be taken as a simple augment of the girth, for if fell off in value as speed increased. In addition to the edge effect there was an increase in resistance, which was probably due to unstable motion around the keel.

Mr. M. P. Payne asked the author to add to the paper a curve for the 28ft. plank which would give the specific resistance of the plank excluding the free surface effect, the lower edge effect, and the wave-making resistance. He agreed with Mr. Perring that caution must be displayed in accepting the opinion of Dr. Kempf that after a certain initial length the length effect ceased.

Mr. W. J. Luke asked for information concerning the degree of smoothness which had been attained in the experiments described. A definition of smoothness was needed for work of that class. Mr. Perring's experiments on a 28ft. plank were valuable, and he hoped he would do further work with much longer planks.

Professor Carter said it had been suggested that the amount of the edge effect or its equivalent, the girth augment, would have been appreciated better if the scale of Fig. 2 in the paper had been larger. The section of model 660 C was less unlike a ship than the other models, but was still far from representing an ordinary vessel. It appeared from the work done by the author that the edge effect was of negligible importance in the case of an ordinary ship.

Commander Hunsaker agreed with Mr. Luke as to the need of defining exactly what was meant by smoothness. That was the crux of the whole matter. On the practical side no doubt mistakes were made, but it was the same mistake which was committed each time, and in the end the predictions concerning speed came out fairly correct except in the case of high speeds of 35 knots and upwards. It was interesting to know that Mr. Kempf had arranged to fit on a new Hamburg-Amerika ship two movable planks in the hull to measure the resistance of the ship at sea.

Mr. Perring in a brief reply said that the question of smoothness was somewhat difficult, and he was not sure how far it would be possible to obtain a definition. It was quite true, as Mr. Payne had pointed out, that the application of the Froude extension data to the O.M. values did result in a slightly lower curve than was shown in Fig. 4 of the paper.

At the evening meeting on March 25th two papers were down for discussion, both dealing with wave resistance.

The first of these contributions, of which Mr. J. L. Kent was the author, described "Experiments on Mercantile Ship Models in Waves."

EXPERIMENTS ON MERCANTILE SHIP MODELS IN WAVES.

This paper records some further experiments with mercantile ship models of varying fullness of form which were carried out at the William Froude National Tank in continuation of the investigation of ship resistance under service conditions which were approved by the Tank Advisory Committee in 1920. The author's 1922 and 1924 papers printed in the "Transactions" should also be consulted. In the present set of experiments five models, each 16ft. in length, with differing fullness of form and corresponding to 400ft. ships with a 55ft. beam, were tested. The models were run in smooth water and then in artificial waves corresponding to lengths of 190ft. and 560ft. and heights of 4ft. and 8ft., at speeds varying from 12·07 to 13·93 knots. The pitching and dipping obtained is described and compared with pitching results obtained on ships at sea. The chief causes producing the complex motions of ships at sea are discussed, particularly the movement of the wave crest along the ship form in successive pitches and dips, and its effect on the ship's ability to avoid shipping seas. Some general conclusions as to the water shipped during the model experiments are given.

Mr. W. J. Berry said he was rather surprised to find that the amount of water taken over did not depend on the fullness of the ship. The fact that a ship was more likely to take in water on a longer range of wave length was confirmed by experience with the very fine ships of the Navy, and the paper gave the first explanation why that should be the case.

Mr. W. G. Perring commented on the proof given by Mr. Kent's experiments that with big heaving forces the loss of speed reached a maximum. He believed that the author had a great deal more information on the general subject, as he had experimented with several models, and it would add to the value of the paper if the data in those other cases could be included.

Mr. Lloyd Woolard challenged the smooth water test results and the relative speeds that had been taken from the vessels according to fineness or fulness. Mr. Kent had done very useful work, but his results would have more direct application to actual ships if the finer models were run at somewhat higher speeds.

Mr. A. L. Ayre expressed the opinion that model experiments could only be considered of great value within definite limitations, and that the time was arriving when it might be useful in work of that kind to have a standard block coefficient. Speaking from experience with a large number of cargo boats, there were definite indications of hump speeds. The fact that the fuller form of boat gave a better result than the other when shipping seas was being investigated had been borne out in practice in the North Sea in ships from 250ft. to 300ft. long.

Mr. Baker, replying in the absence of the author, said he would hardly be doing Mr. Kent justice if he attempted to answer any of the contributors to the discussion himself. He would consider very carefully, however, what had been said with regard to the question of speed at which the models should have been run. Their programme was never a rigidly fixed one and if they could they would try to meet the queries about results of higher speeds. He did not know whether Mr. Kent had any data of that nature up his sleeve. If not, they could run one or two of the models at higher speed and that would form part of some additional contribution in the future.

Mr. W. C. S. Wigley then presented a paper on "Ship Wave Resistance: A Comparison of Mathematical Theory with Experimental Results."

SHIP WAVE RESISTANCE: A COMPARISON OF MATHEMATICAL THEORY WITH EXPERIMENTAL RESULTS.

The object of this paper is to determine the order of accuracy of the agreement between the mathematical theory of ship wave resistance in its present state and the results of experiment.

For this purpose three models of forms, as ship-shape as possible, derived from mathematical equations which lend themselves to calculation, have been made and tested in the Tank. The resistance and other phenomena of the motion have been calculated, first from the equations derived from the theory, and, secondly, from the model tests, using Froude's friction data in obtaining residuary resistance, and comparisons in detail have been made between the two sets of results and are described in the paper.

A mathematical investigation into the order of the possible error arising from certain assumptions in the mathematical theory has also been made.

Mr. Lloyd Woolard regarded the contribution as of great importance to all those who were interested in the application of mathematical theory to ship resistance. The problem at first sight presented

almost insuperable difficulties, but the author had shown that a remarkable measure of qualitative agreement was obtainable, and in one case at least there was some degree of confirmation quantitatively. As further justification for the theory, were justification necessary, the results obtained theoretically for each of the three ideal forms agreed with those given by Havelock's formula, although the two methods in themselves were quite different. The paper presented a good opportunity for testing the accuracy of methods for predicting critical speeds. According to one view, introduced by Baker, the wave-making distance (*i.e.*, the distance between the first bow crest and the first stern trough) increased with speed. The other theory, due to R. E. Froude, was that it was constant. Both rules were empirical and both had received experimental support. Examination of the curves in the paper indicated that neither in the calculated nor in the observed resistance curves did the humps and hollows agree with those deduced from either of the rules mentioned. On the other hand, the critical speeds were more nearly in agreement with those calculated from Froude's assumption. There was a variation of wave-making distance with speed, but not quite so rapid as that implied by Baker's theory. That was in agreement with the conclusion arrived at by Professor Havelock in a paper read before the Royal Society last year, and Mr. Wigley had made a very useful contribution to the theory of waves and wave resistance.

Mr. F. Bailey, in a written contribution which was read by Mr. M. P. Payne, said the degree of agreement obtained by Mr. Wigley between theory and experiment was most important for the future development of the subject of ship resistance. Considering the approximations which had to be made at present in attempting to calculate the wave-making resistance of a ship the order of accuracy obtained, particularly with model 755, was greater than one would have anticipated. One result of treating the beam of the model as infinitely small, which was not directly shown in the paper, was that the theoretical resistance was proportional to the square of the beam. That was certainly not generally true of actual ships, and it would appear to be well worth while running a model to the lines of No. 755 with the beam scale reduced, particularly as the length displacement ratio of that form was low for a high-speed ship.

Mr. G. S. Baker said that as a result of the work of Professor Havelock naval architects had now a passing acquaintance with such mathematical work as formed the foundation of Mr. Wigley's paper. A considerable amount of data had been slowly accumulated, all based on such work and all open to question owing to the assumptions made, and to the fact that the work had not been checked by experiment, so far as he knew. Mr. Wigley had stepped in and with much labour filled the gap. It was shown that the assumption as regarded smallness of angle of entrance was probably not serious, and by experiment it was determined that the trim changes which occurred in the model had relatively small effect in general. It was found, however, that the influence of turbulence could not be neglected, and that it was impossible to obtain comparable experimental results with forms which induced eddy making, as the errors were larger, in some cases over 100 per cent. Model 714 showed the effect of eddies around the sharp bilge, a motion ignored in calculations. The effect of viscosity was neglected in the equations of motion. More light should be thrown on the whole subject from the work now in hand and in contemplation.

A NEW GERMAN STEEL AND COAL TRUST.

A MESSAGE from Berlin dated March 26th, states that the Rhenish Westphalian Steel Trust, which is to be known as the Vereinigte Stahlwerke, has now to all intents and purposes been constituted, and begins active operations on April 18th. All that is now required is to obtain the sanction of the shareholders of the various concerns in the Trust, namely, the Phœnix, the Rheinstahl, the "Gelsenkirchen and Bochumer" Verein, the Deutsche Luxemburg and the Vanderzypenwissen, and that would, it is stated, be forthcoming at the general meetings, some of which were to be held within the next following days. The firm of Herr August Thyssen, which is a private undertaking, is also a member of the Trust.

At the meeting of the Phœnix Company, which was held on March 26th, Herr Fahrenhorst, a director, stated that the purpose of the new Trust was to reduce general expenditure by concentration of production in such a manner that the various works would turn out the material for which they were best suited. The reorganisation would entail the cutting down of freights to a minimum, and some workshops would have to be closed, but he did not believe, he said, that it would be necessary to dismiss either officials or workmen, as the reduced costs of production would, it was hoped, bring down the prices and consequently lead to greater home and export trade.

The headquarters of the Trust will be Düsseldorf for steel and Essen for the coal industry. The capital of the steel trust is fixed at 800,000,000 marks, and it is hoped to obtain the necessary working capital by means of long term loans.

A COMPANY has been formed in Canada with the object of constructing three tunnels under the Detroit River between Detroit and Windsor. One of the tunnels will be used for electric cars and the two others for motor cars.

The M.A.N. Double-acting Marine Oil Engine.

No. II.*

TESTS AND TRIAL RESULTS.

THE six-cylinder 4400 brake horse-power oil engine operating on the double-acting two-cycle principle, which was described and illustrated in our last issue, was built for the cargo vessel Ramses, which belongs to the German-Australian and Kosmos Lines. During the month of January it was subjected to a full series of bench trials at the works of its builders, the Maschinenfabrik Augsburg-Nürnberg A.G., at Augsburg. We had the pleasure of inspecting the engine while it was on test, and in what follows some account of the trials and the results obtained is given. The figures are of interest because although a large amount of information is now available concerning the performance of single-acting engines, there is less data with regard to double-acting two-cycle engines.

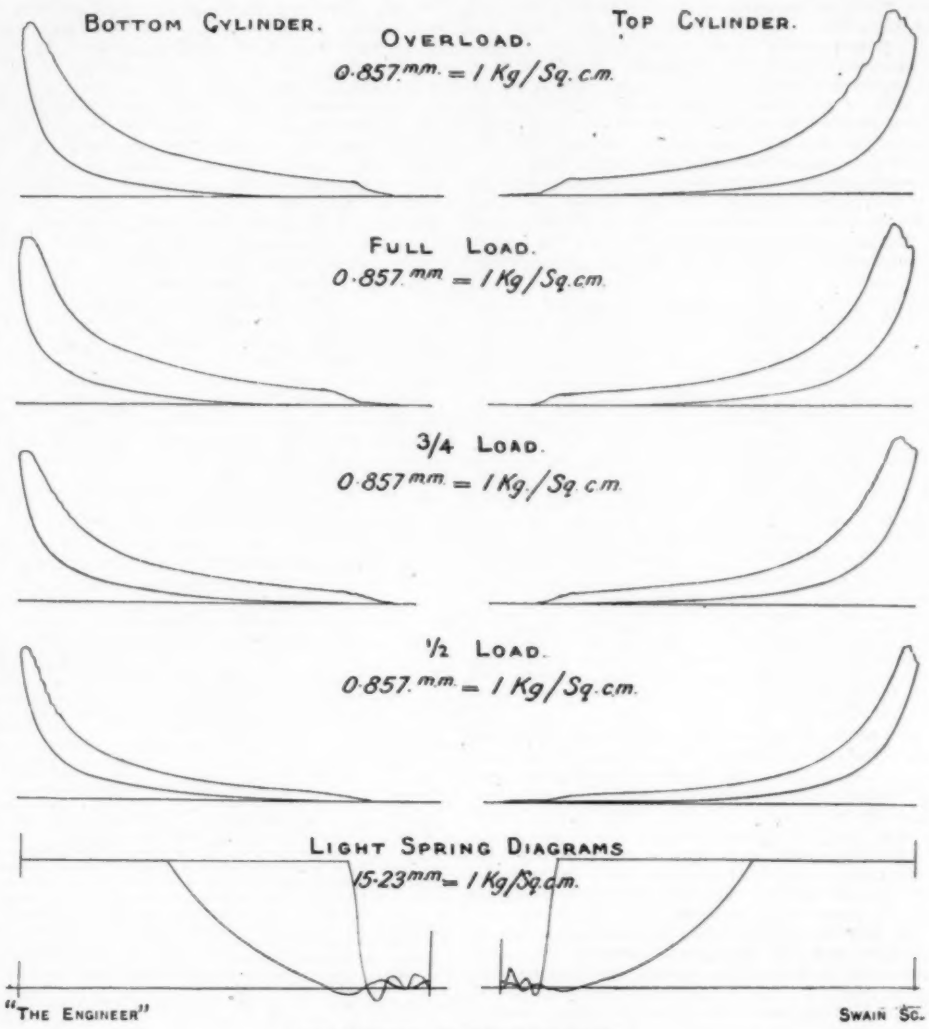


FIG. 5—TYPICAL INDICATOR DIAGRAMS

It will be recalled that the engine was designed to develop 4400 brake horse-power in six cylinders, each of 700 mm. diameter, with a piston stroke of 1200 mm., and that the normal running speed for this load was 84 revolutions per minute. The trials run included four at full, three-quarters, half and quarter loads respectively, together with overload and light running trials. In Fig. 5 we reproduce photographs made to actual size of typical diagrams taken during these trials. The good general shape of the diagrams may be noted, and the bottom and top cylinder cards compared, it being borne in mind that the total capacity of the bottom cylinder is only about 85 per cent. of that of the top cylinder.

For the purpose of testing, the load was applied by three direct-current generators geared to the shaft. Suitable precision instruments were arranged for measuring the ahead and astern loads, and for determining the power required by the two electrically driven turbo blowers which supplied the scavenging air. Arrangements were made for weighing the fuel oil used. The amount of scavenging air required was obtained from an analysis of the exhaust gases and by measurement of the velocity of the air in the scavenge mains. For this purpose a number of Pitot tubes, arranged at various sections in the mains, were employed. There was close agreement between the results obtained by the two methods. At the exhaust ports and in three different positions in the exhaust pipes, the exhaust gas temperatures were measured by iron-constantan thermo-couples, and at one position these readings were checked by a nitrogen-mercury thermometer. The temperature curve for different loads is given in Fig. 6. Gas samples were also taken and were analysed by an Orsat apparatus.

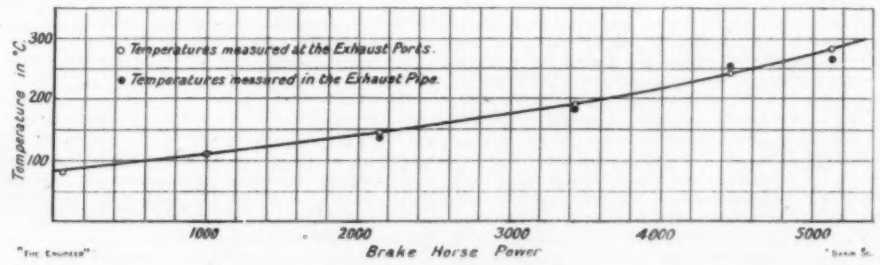


FIG. 6—EXHAUST TEMPERATURES

The chief results of the trials—which lasted over 180 hours—are given in the accompanying curves and tables. A fuel oil known in Germany as Diesel Oil No. 1, supplied by the German-American Petroleum Company, of Hamburg, was used, and it had the following physical characteristics:—Specific gravity at 15 deg. Cent., 0·881; viscosity at 20 deg. Cent., in degrees Engler, 2·1, and 1·4 at 50 deg. Cent.; the flash-point in open crucible test was 99 deg. Cent.; there was a coke residue of 0·95 per cent. with an ash content of 0·03 per cent., and 0·07 per cent. of the oil was insoluble in benzine. Chemical analysis showed a carbon content of 86 per cent., hydrogen

* No. I. appeared March 26th.

12·6 per cent., and sulphur 1·25 per cent. The oil had a lower calorific value of 10,125 kilo-calories per kilogramme; when subjected to fractional distillation the oil started to distil over at 210 deg. Cent., at 250 deg. 26 per cent. passed over, at 300 deg. to 18,000 B.Th.U. per pound. It is of interest to note that the full load fuel consumption at 4400 brake horse-power at the engine shaft, with a speed of 84 revolutions per minute, after taking into account the power required by the turbo-blower—see Fig. 8—

TABLE I.

Trial.	B.H.P.	R.P.M.	Power taken by blowers. No. I.	Power taken by blowers. No. II.	Scavenge air pressure in atmospheres.	Fuel consumption, grammes per B.H.P. hr. Without blower.	Fuel consumption, grammes per B.H.P. hr. With blower.	Heat rejected in the cooling water in kilo.-calories per B.H.P. per hour. Cylinders, 1–6.	Pistons 1–6.	Air compressor.	Intercoolers Nos. I. and II	Total.
Full load	4460	83·5	104	104	0·09	173·9	182·85	380	157	9	28·	574
Three-quarter load	3435	83·6	104	107	0·09	175·9	187·0	342	174	10·9	35	561·9
Half-load	2150	84	103·5	104	0·09	189·5	210·2	307	245	21·4	38	671·4
Quarter load	1000	81	103	104	0·09	280·0	353·6	580	429	39·0	128·7	1176·7
Running light	—	83·5	102·5	103	0·09	142*	—	—	—	—	—	—
Overload	5130	84	102	105	0·09	178·1	186·0	378	157·6	10·47	28·94	575

* Kilogrammes per hour.

TABLE II.

Test No.	B.H.P.	R.P.M.	Scavenge air pressure in atmos.	Composition of exhaust gases. Per cent. CO_2.	Composition of exhaust gases. Per cent. CO.	Scavenge air cub. metres per sec.	Air used.	Fuel consumption in grammes per B.H.P. hr. Without blower.	Fuel consumption in grammes per B.H.P. hr. With blower.
1	4355	83·5	0·07	4·57	14·75	8·44	1·155	178·6	185
2	4460	83·5	0·09	3·9	15·65	10·03	1·37	174·6	182·8
3	4440	83·5	0·11	3·48	16·22	10·9	1·49	172·5	184

TABLE III.—*Manœuvring Trials.*

No.	Telegraph order. Direction.	Telegraph order. Speed.	Speed on Tacheometer.	Time in seconds between giving of order and. Engine stopped.	Time in seconds between giving of order and. First firing stroke in new direction	Time in seconds between giving of order and. End of manœuvre	Atmospheres pressure in starting receivers. Before manœuvre	Atmospheres pressure in starting receivers. After manœuvre	Atmospheres pressure in starting receivers. Drop in pressure.
1	Ahead	Slow	—	—	—	—	—	—	—
2	Astern	Slow	45	—	—	13	64·2	62	2·2
3	Ahead	Slow	45	5	7	11	63·2	61·4	1·8
4	Stop	—	—	4	—	—	—	—	—
5	Astern	Slow	70	—	5	12	59·8	58·2	1·6
6	Ahead	Slow	—	—	—	—	—	—	—
7	Stop	—	—	5	—	—	59·2	—	—
8	Ahead	Half	80	—	2	10	59·2	57	2·2
9	Astern	Half	80	6	12	22	58·4	56	2·4
10	Stop	Stop	—	13	—	—	57·4	—	—
11	Ahead	Full	84	—	4	12	57·4	55	2·4
12	Astern	Full	84	8	12	20	56·4	54	2·4
13	Ahead	Full	84	7	11	18	55·2	53	2·2
14	Astern	Full	84	9	12	18	54·4	52	2·4
15	Ahead	Very slow	30	7	12	25	54·4	52	2·4
16	Astern	Slow	45	6	10	20	52	49·8	2·2
17	Ahead	Half	70	10	15	25	50·4	48·8	1·6
18	Astern	Full	84	8	11	16	49·6	47·4	2·2
19	Ahead	Full	84	8	10	16	47·7	45·3	2·4
20	Astern	Full	—	—	—	—	—	—	—

54 per cent., and at 350 deg. Cent. 72 per cent. The residue was viscous and black in appearance.

In Table I. the performance of the engine at various loads is given, together with the fuel consumption, turbo-blower powers, and the heat rejected

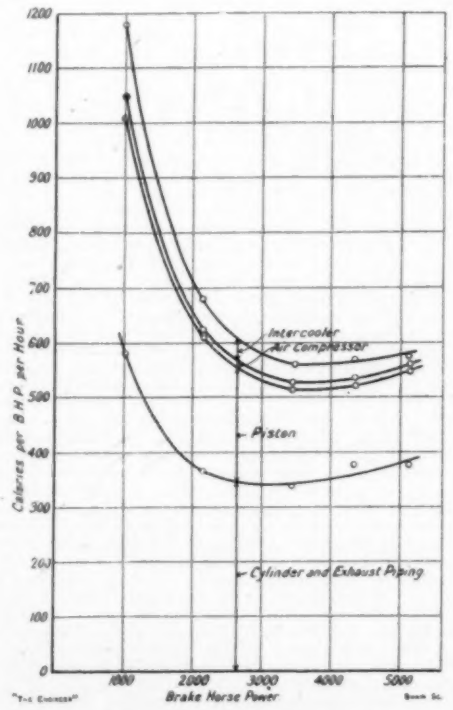


FIG. 7—COOLING WATER HEAT LOSSES

in cylinder jackets, pistons, compressor and intercoolers. The heat losses and fuel consumptions are also shown graphically in Figs. 7 and 8. In making the curves the calorific value of the fuel was taken as 10,000 kilo-calories per kilogramme, corresponding to 18,000 B.Th.U. per pound. It is of interest to note that the full load fuel consumption at 4400 brake horse-power at the engine shaft, with a speed of 84 revolutions per minute, after taking into account the power required by the turbo-blower—see Fig. 8—was 182·8 grammes, or 0·401 lb. per brake horse-power. The brake mean effective pressure in the working cylinders was 4·5 kilos. per square centimetre, or about 64 lb. per square inch, a figure which is indicative of the conservative manner in which the engine is rated.

Under full load running conditions, corresponding to 4460 brake horse-power at a speed of 83·5 revolutions per minute, the indicated horse-power was 5320, and the corresponding mean indicated pressure 5·5 kilos. per square centimetre, or 78 lb. per square inch. The mechanical efficiency without the blowers was 84 per cent., and with the blowers taken into account 80 per cent. With the engine running light a brake horse-power of 860 was recorded, and the two turbo-blowers took 208 brake horse-power.

For a trial which was run at full load and a normal speed of 84 revolutions per minute, the following thermal balance was obtained.

Item.	Kilo.-calories per B.H.P. hour. Without blower.	Kilo.-calories per B.H.P. hour. With blower.	Percentage efficiency. Without blower.	Percentage efficiency. With blower.
Heat in fuel oil	1750	1840	100	100
Rejected in cooling water	574	602	32·8	32·8
Heat of exhaust gases, including radiation	422·4	447	24·14	24·14
Friction	94	99	5·38	5·38
Effective horse-power	632	632	36·1	34·42
Scavenge blowers	—	31	—	1·68
Compressor I.H.P.	27·6	29	1·58	1·58

During the tests the admission temperature of the cooling water was from 25 deg. to 30 deg. Cent. The volume of water passing was determined by measuring tanks, but the amount of cylinder cooling water was tested by nozzles.

The heat carried away by the cooling water in various parts of the engine is shown in Table I. and graphically in curve Fig. 7.

An interesting part of the test was the determination of the amount of air used, which is also shown for three different scavenge air pressures—see Table II. and curve Fig. 9.

Table III. gives details of the manœuvring trials, which comprise fourteen different manœuvres, in which the drop in pressure in the starting receivers was recorded before and after each individual operation. Altogether ten starting receivers were used, each with a capacity of 1200 litres. The total fall in pressure for the fourteen operations was 30·4 atmospheres, and the total air used 365,000 litres, which corresponded to 26,000 litres per manœuvre. With a total stroke-volume for the engine of 5252 litres the air used per manœuvre was therefore 4·95, or nearly five times the stroke-volume of the engine. It will be noted that there was a slight rise in pressure after each manœuvre, from which it would appear that the compressor was delivering air tb the system as under sea conditions.

The running of the engine during the whole of the trials was without incident, and good combustion was maintained at all loads, with a colourless exhaust. After the trials the unit was opened out and found to be in a very satisfactory condition. The cylinder spaces and piston heads showed very little carbon deposit, and with the exception of a slight tightness on two of the piston rings, all rings were quite loose and in a well-lubricated condition. No wear was noted on the piston-rods, which were well polished, the stuffing-box rings bearing equally. The liners were found to be in excellent condition, and the exhaust ports clean, whilst the lubrication appeared to be equally distributed. There was no sign of wear in the liners, and the machining marks were still visible. Examination of the various valves showed that all the valves, including the starting valves, were tight, and no joints were broken. The main bearings were in good condition, and the load on the crankshaft was evenly borne.

FUTURE DEVELOPMENTS.

Since the tests were completed new contracts have been added to the orders already in hand, which would appear to justify the confidence the builders

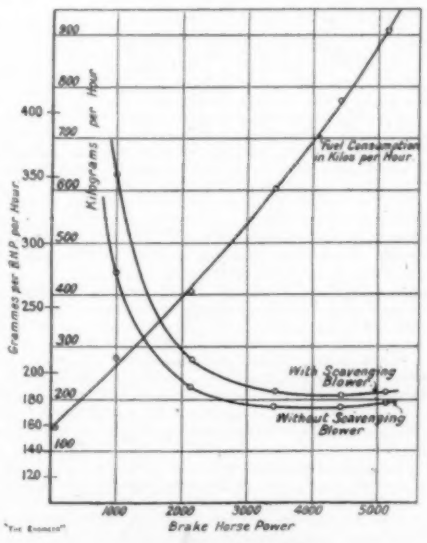


FIG. 8 FUEL CONSUMPTIONS

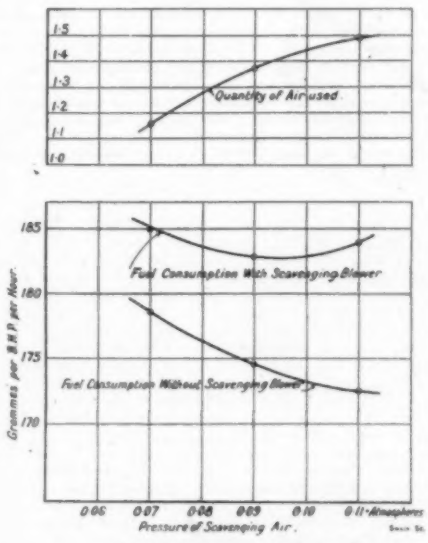

Quantity of Air used
Fuel Consumption With Scavenging Blower
Fuel Consumption Without Scavenging Blower
Grammes per B.H.P. per Hour
Pressure of Scavenging Air

FIG. 9—FUEL AND AIR USED

feel in this type of marine oil engine. In Holland the Rotterdam Lloyd Company recently ordered a cargo and passenger vessel from the Fijenoord Shipbuilding Company, in which a seven-cylinder engine, designed for an output of 5200 shaft horse-power at a normal speed of 86 revolutions, will be installed. The engine will be built under licence from the M.A.N. Company. Another licensee, the Weser A.G., of Bremen, will build two 4000 brake horse-power engines for 76

revolutions per minute, which are to be put into two cargo ships for the Hansa Line. It will be remembered that Blohm and Voss, of Hamburg, have already built a six-cylinder engine of the same type for the German-Australian and Kosmos Line vessel Magdeburg, which has now been in service for some months, and is, we learn, giving good results.

The same firm of builders is now completing the erection of the nine-cylinder 15,000 brake horse-power engine at the Hamburg Electricity Works, a preliminary description of which engine appeared in The Engineer of January 29th. In America this type of engine is being built by the Hooven, Owens, Rentschler Company, of Hamilton, Ohio, and the Hamilton and Electric Boat Company, of New York, each of which firms is constructing a four-cylinder 3500 shaft horse-power unit for ships of the United States Shipping Board. Four other engines of the type we have described are now in course of construction at the works of the Cantieri Officine Savoia, Cornigliano, Ligure, Italy, for the new passenger liner Augustus, which is being built by Ansaldo at Sestri Ponente for the Navigazione Generale Italiana, of Genoa. She is a quadruple-screw vessel of 31,000 gross tons, and her four 6250 brake horse-power, 120 revolutions per minute, engines are designed to give a speed of 21 knots. The engines are capable of an overload rating of 7000 brake horse-power each at 125 revolutions. Apart from the double-acting engine we have mentioned, a large number of single-acting motors with the same type of scavenging arrangement are being built. The builders inform us that they see no difficulty in the way of constructing 20,000 brake horse-power units on a single shaft.

In addition to the developments to which we have referred, negotiations for the construction of this type of engine are proceeding with British shipbuilding firms.

Books of Reference.

The publication of the "Directory of Contractors and Public Works Annual," which was established over a third of a century ago, was suspended during the war, and was only resumed last year. The 1926 edition, which is obtainable for 15s. from Wightman and Co., Ltd., 104, Regency-street, Westminster, S.W. 1, appears in a considerably extended form, containing as it does upwards of 150 pages more than its immediate forerunner. In addition to the lists of contractors, engineers, architects, officers of public bodies, &c., which appeared in the 1925 edition, we notice the following further lists:—(*a*) Admiralty (Civil Engineering and Contract and Purchase Departments); (*b*) Civil Engineers (Consulting and Constructive); (*c*) Commercial Industrial Engineers; (*d*) Gaswork Engineers, Managers and Consultants; (*e*) Irish Free State Secretaries, Clerks and Surveyors; (*f*) Ministry of Transport; and (*g*) Steel House Contractors. These additions have made an already useful book considerably more valuable as a work of reference.

From the "Year Book for 1926" of the Institution of Structural Engineers we learn that since the publication of the last Year Book in July, 1924, that is to say, in eighteen months, the membership of the society has doubled. The total number of honorary members and associates, members, associates, associate members, graduates and students on the register on January 7th last was 2429. In addition to full lists of members of all classes, the Year Book contains a summary of the activities of the association, with lists of its officers and committees, a copy of the rules for the professional practice and scale of fees of members practising as consulting engineers, reprints of the memorandum of association and articles of association, &c. The Year Book is published at the offices of the Institution, Abbey House, 2–8, Victoria-street, London, S.W. 1, price 3s. 6d. to non-members.

The Motor Ship Reference Book for 1926. London: Temple Press, Ltd., 7–15, Rosebery-avenue, E.C. 1. Price 5s. net.—This useful little volume, which is compiled by the editorial staff of our contemporary, the *Motor Ship*, appears in the 1926 edition for the second time. Like the previous edition, it contains a brief survey of the history and progress of the motor ship, with an account of the principal types of propelling machinery employed. Particulars of the new double-acting and single-acting engines first commercially developed in 1925 have been added to the previous description, so that the range now includes an illustrated description of almost every type of oil engine which is employed to any extent in motor vessels. The illustrations are well reproduced and clear drawings accompany the descriptions of the engines. The new edition includes fresh statistical matter and a new section has been added in which the leading features of motor ship and marine oil engine development in 1925 are given. The book is one which should prove of service to shipowners, shipbuilders, oil engine manufacturers and others who desire to keep abreast of the rapid progress which is being made in this particular branch of marine engineering.

Handbuch der Schiffbau-Industrie. Deutsche Wirtschaftsbucherei, Vol. II. Berlin: Mundus Verlagsanstalt G.m.b.H., Charlottenburg 4. 1925. Price 15 marks.—This volume is the second of a series of four dealing with various branches of German industry. The volumes so far issued include those for the oil, shipbuilding, gas and paint and colour industries, and others, we learn, are in preparation. Very extensive changes have taken place in shipbuilding circles in Germany during the last ten years, and it is very convenient to have in a single book complete information as to the present state of the industry. In the first part of the book particulars of the various shipbuilding firms are arranged according to the towns in which the yards are situated. A full account of each undertaking with the list of directors and managers is given, as is also a brief description of the capacity of the yard and the class of work done. This part of the book consists of three sections, shipbuilders proper, constructors of boats for rivers and inland lakes, and builders of yachts and pleasure craft. Thereafter follows a section giving the officers and members of the three most important German shipbuilders' associations, Verein Deutscher Schiffwerften E.V., Verein der Flusschiffswerften Deutschlands E.V., and the Schiffbautechnischen Gesellschaft. A further section of the volume is devoted to the Hamburg and the Berlin experimental tanks. Various statistical tables of German and international shipbuilding returns are given, and the volume is provided with an excellent index of shipbuilding firms.

"Sell's Directory of Registered Telegraphic Addresses," which is published by Business Dictionaries, Ltd., of 8 and 9, Johnson's-court, Fleet-street, London, E.C. 4, price 45s. net, attains, in its 1926 edition, the forty-first year of publication. This book of reference is one of the most frequently consulted among office books. It is in fact invaluable, and during the many years that we have used it, we have never found any mistake in it. It needs no word of description from us, for it is now too well known, but we may say that in addition to the lists of names and addresses, both telegraphic and full, for both London and the country, the telephone numbers, where there are any, are also given. The Classified Trades List is also an exceedingly useful feature; and there is any amount of other information which we are continually finding of service.

Letters to the Editor.

(*We do not hold ourselves responsible for the opinions of our correspondents.*)

THE CHOICE OF STEEL FOR ENGINEERING WORK.

Sir,—I was very much interested in Mr. Mohn's remarks under the above heading, which appeared in your issue of the 26th ult. As it would appear that Mr. Mohn has not seen a copy of the paper in question, I am enclosing one, which I should be glad if you would pass on to him.

Regarding the effects of sharp corners. The writer agrees that there may probably be other causes of breakdown of more importance, but since the particular references to failures of this kind were included under the heading "Concentration of Stress," and since in the lecture it was specifically stated that in each case quoted investigation had shown that no other cause of failure existed, then it was perfectly justifiable to lay all the blame possible on the presence of such sharp corners, &c.

With regard to the query as to why a 2in. bar sawn a quarter way through would, when given a blow, break more easily than a 1in. bar not so treated, the effect of the saw cut is to induce such concentration of stress at the root that the ultimate stress of the material is exceeded; a crack is produced and the bar may break. In the case of the 1in. bar without a saw cut the stress applied is absorbed over a large area and so dissipated before the stress can reach that of the ultimate stress; no crack is produced and the bar remains intact. For example, an Izod piece with standard vee notch made from a piece of railway tire material may absorb 10 foot-pounds before fracture. If a round notch is substituted, 20 foot-pounds may be required to bring about fracture; if unnotched, 120 foot-pounds may be absorbed and the piece of steel remain unbroken.

With regard to the mounting of tram wheels and gear wheels on axles, &c., there is no doubt that unless precautions are taken to remove anything in the nature of an acute fillet or abrupt change of section, trouble may and does arise, and too much emphasis cannot be laid on this.

With reference to the failure of the overhung crank of a steam engine, the direct cause of fracture would be the overstress which produced the initial crack. The appearance of the fracture ultimately resulting would be that due to a slowly creeping crack and would be of the fatigue type.

There is no relationship between the modulus of elasticity and the figures obtained from the notched bar test. As the properties of materials represented by these are so fundamentally different it is difficult to see how there could be. A. P. Hague.

Sheffield, March 25th.

ELECTRICITY SUPPLY.

Sir,—The leading article in the issue of The Engineer for the 19th inst., pages 327–8, calls attention to a number of important considerations which will require to be very carefully weighed against the anticipated reduction in the cost of generation under the Government scheme in order to arrive at the true overall cost, which latter is the figure on which the charge to the consumer is based and consequently the only one likely to interest him. Seeing that the cost of generation is only about 20 per cent. of the total cost of electricity as usually supplied to towns, the inevitable increase in the cost of distribution under the proposed scheme may easily wipe out any saving effected by more economical generation.

But why perpetuate a system of generation which absolutely throws away the heat in the exhaust steam, corresponding to about 60 per cent. of the total heat in the coal, with the result that the most economical super station in Great Britain (Barton, Manchester) only gives a thermal or heat efficiency of 20·33 per cent. and requires 1·35 lb. of coal per unit. Compared with this, as far back as the year 1912, a small power plant of only 300 kilowatts capacity required only 0·45 lb. of coal per unit—see The Engineer, February 16th, 1912. This is a case where the exhaust steam is usefully employed for process work and heating.

Further, what is the use of offering a supply of electricity at a penny per unit to firms who must have steam for heating and who, by generating with their own plant and utilising the exhaust steam at whatever pressure and temperature they may require it, are obtaining current at half the cost, which in more than one instance has resulted in a saving of £20,000 per annum? Even a small 75-kilowatt set operating on these lines is generating at 0·55 pence per unit including all charges, and the distribution costs are practically nil, seeing that the current is used on the premises.

Moreover, on this economical system of working the results are forthcoming without the extreme steam conditions or the grand elaboration of costly instruments and the highly trained technical staff which is considered necessary to secure the last 1 or 2 per cent. of the miserably low efficiency shown by even our best super station run on ordinary lines.

The two examples given could be, and have repeatedly been, supported by many others equally striking, but the system of operation by which the figures were obtained nevertheless appears to have been overlooked in framing the new proposals. As there are a large number of plants operating on these lines at the leading works, hotels and institutions throughout the country and abroad, there is no excuse for not making an investigation of the system. A number of such installations could be fully inspected and reported upon; indeed, the owners would often welcome such inspection. As a matter of interest, combined power and heating was in use at the Grand and Midland Hotels, Birmingham, at the time of the visit of Mr. Baldwin, when he outlined the Government proposals.

It only requires a well-considered extension of this system and the helpful co-operation of firms requiring steam for heating purposes with the electric supply authorities to evolve a scheme which will save far more than any super power scheme run on ordinary lines, besides giving many incidental advantages.

Now is the time for a full consideration of the whole question; it will soon be too late. What have your readers to say on the subject? J. F. Raggett.

March 25th.

SUPER-ACCURACY.

Sir,—In your issue for March 19th there is an article with the amazing title "The Super-accurate Production of Spur Wheels on the Gear Shaper," and I confess to being puzzled by it. Surely there is no such thing as super-accuracy.

A product either is accurate or inaccurate; there are no degrees of accuracy. If it is accurate, good and well; if inaccurate, it is necessary usually to specify the amount by which accuracy is missed. It is possible to conceive of articles being so well made that they possess a very close approximation to accuracy. Anything which is claimed to be still better than accurate should be looked at with suspicion.

The sum of two and two is four; this result is accurate. May one ask if super-accuracy makes the result come to five, in which case there may be a hint to the solution of the conundrum, "How many beans make five"?

Undoubtedly some English words have changed their meaning with time, but the ancestry of this word should ensure its correct use for many a long day.

My dictionary tells me it comes from *ac* = *ad* = to and *cura* = care, and therefore signifies that an operation, say, has been carried out with care for the resulting product to be "exact without error or defect, free from mistake." Anything consequently that claims to be better than accurate can be only superficial and without any depth at all. A. F. A.

March 25th.

INSTITUTION OF ELECTRICAL ENGINEERS.

The summer meeting of the Institution of Electrical Engineers will be held in the North-Eastern Centre of that body from June 8th to 11th next. A Registration and Information Office, with attendant and telephone, will be provided at the Central Station Hotel, Newcastle-upon-Tyne, and will be open during the evening of Monday, June 7th. On the same evening there will be a reception from 7 to 8.30 p.m. in the Banqueting Hall at the Central Station Hotel.

For the meeting proper the following programme has been arranged. During the morning of Tuesday, June 8th, there will be alternative visits to:—(1) The Elswick Works of Sir W. G. Armstrong, Whitworth and Co., Ltd.; and (2) the works of J. H. Holmes and Co., Ltd. In the afternoon there will be a visit to the Heaton Works of C. A. Parsons and Co., Ltd., and in the evening a Civic Reception at the Oxford Galleries, New Bridge-street, Newcastle, by the Rt. Hon. the Lord Mayor of Newcastle-upon-Tyne (Councillor Anthony Oates) and the Lady Mayoress.

On the Wednesday morning a visit will be paid to the North Tees Power Station of the Newcastle-upon-Tyne Electric Supply Company, Ltd., and associated companies, and in the afternoon there will be alternative visits to:—(1) Durham, to see the Cathedral; (2) the Horden Colliery of the Horden Collieries, Ltd. In the evening there will be a reception and dance at the Grand Assembly Rooms, Barras Bridge, Newcastle, as the guests of the principal (Sir Theodore Morison, K.C.S.I., K.C.I.E., C.B.E.) and the Council of the Armstrong College, Newcastle-upon-Tyne. It is expected that the new library of the College, which is quite close to the Grand Assembly Rooms, will be available for inspection by those who are interested.

On the Thursday morning a visit will be paid to the works of A. Reyrolle and Co., Ltd., Hebburn-on-Tyne, and in the afternoon alternative visits to:—(1) The Lemington Glass Works of the General Electric Company, Ltd.; and (2) the Wallsend Shipyard of Swan, Hunter and Wigham Richardson, Ltd. For the evening, to meet the wishes of visitors expressed at some of the previous summer meetings, no formal plans have been made.

On the Friday morning there will be alternative visits to:—(1) The new Steel Works and Rolling Mills of the Consett Iron Company, Ltd; and (2) to Hexham and the Abbey. In the afternoon both parties will unite for a visit to the Roman Wall and the Roman Camp of Borcovicus. The party will return *viâ* the line of route of the Roman Wall, Chollerford—on the North Tyne—and the Western Turnpike. In the evening there will be a reception and dance at the Old Assembly Rooms, Westgate-road, Newcastle.

Applications to take part in the meeting should be made to the secretary of the Institution on a special form not later than April 8th.

The Chute des Chats Falls on the Ottawa River are to be utilised for the development of power to supply the lead mines at Galetta, Ontario.

Railway Matters.

THE London and North-Eastern Railway has withdrawn from its waiting-rooms the notice prohibiting smoking therein, which was "an offence" as long ago as 1842.

THE Bill promoted by the London, Midland and Scottish and the London and North-Eastern companies jointly for the Mid-Nottinghamshire Joint Railway, has passed through the Committee stage of the House of Commons.

THE new four-aspect colour light signals, described in this column of our issue of the 12th ult., and installed on the Southern Railway, were brought into use on March 21st between Holborn, St. Paul's and Elephant and Castle. All-electric power signalling was introduced which has allowed five signal-boxes to be dispensed with.

IN this column of our issue of November 6th last, we alluded to the possibilities of additional facilities at Fleetwood for handling the passenger traffic to and from Belfast, and to and from the Isle of Man. There was also the question of providing two additional steamers in the Belfast service. We now hear that Sir Josiah Stamp, the president of the executive, London, Midland and Scottish Railway, was recently in Fleetwood studying the situation.

THE Stationery Office has just published, price 2s., what are known as the Preliminary Railway Returns for 1925 of the Ministry of Transport. The tables show the capital expenditure and receipts, the revenue receipts and expenditure from railway working, the total net receipts, the appropriation of net income and a summarised balance sheet. They also show the number of passengers carried, the tonnage conveyed, the average receipt per ton and per ton mile, and the leading operating statistics. The complete railway returns will be issued later.

WE are informed by the High Commissioner for New Zealand that a sum of approximately £100,000 will be involved in a contract for the erection of new locomotive workshops in the Hutt Valley, Wellington, New Zealand, which it is hoped will be secured by British manufacturers. The New Zealand Government has invited tenders in this country for the work. The provision of heavy cranes is included in the contract. It is understood the present inquiry will be followed by three others for car and wagon shops at Otahuhu, Auckland, and Addington, Christchurch, and for another locomotive workshop at Hillside, Dunedin. The Hutt and Otahuhu workshops will be entirely new, and those at Addington and Hillside are to be remodellings and enlargements of existing works.

THERE has recently been issued the report by Lieut.-Colonel Mount on the collision on October 12th last at Llandudno Station. The points had been set and the signal lowered for an arriving passenger train to run into No. 4 platform road. At that time another train was ready to depart from No. 3 road. As the two movements were conflicting, the signals necessarily were locked against the outgoing train. The latter was of the motor car type, and when the hand signal to depart was given, the guard entered the driving compartment and made a remark, as to a stop at a certain station, to the driver. The attention of the latter was evidently thereby distracted, and the train was allowed to pass the departure signal and to foul the path of the incoming train. In the consequent collision about twenty passengers, mostly school children, were hurt.

IN this column of our issue of the 12th ult. we drew attention to the expenditure on "betterments" in rolling stock being charged to capital. Such items were, we admitted, for additions to what previously existed, but, because they assisted to swell the capital account, we thought it better policy to charge them to revenue. It has now been pointed out to us that the companies have been compelled to take that step because the cost of renewing each unit is now much higher than it was. A wagon, for instance, that cost £60 or so when new, costs between £100 and £120 to replace. Therefore the provision of oil lubrication for grease is put to capital, and so is the equipment of vacuum brake gear or brake pipes. It is further pointed out that as both these additions lead to a reduction in running expenses, it is equitable to charge their provision to capital.

SPEAKING at the recent London and North-Eastern meeting, the chairman said that there had been considerable congestion in the southern area, and that plans were under consideration for dealing with it, so as to get better working for the goods traffic *en route* from the North to London. In explanation of the fact that apparently it has taken the three years since grouping was effective to decide what was wanted, Mr. Whitelaw said that the amalgamation of the companies made considerable changes in the routing of traffic; competitors became allies and former allies became competitors, and what might be called the new normal routes required a good deal of time to get settled. Any attempt to foresee what those new routes were going to be, without waiting for some evidence and experience, would have resulted in all probability in their spending money in wrong places which, while wasting their resources, would have proved of little benefit to traders.

THE cleaning and oiling of switches of points on railways is a duty belonging to the operating department, *i.e.*, it is done by a point cleaner, who is on the pay-roll of the station staff, and is not therefore a concern of either the permanent way or signal department. Yet both the latter are interested, as the former maintains the switches and the latter is responsible for the rodding that works them. To assist in the operation of the points, the slide chairs on which the switches move are oiled by the point cleaner. They, of course, collect dirt which adds to the man's work. Some companies—the Great Western in particular—are using a ball bearing for the switches, which takes the weight of the switch as it moves, and so renders unnecessary the oiling of the slide chairs, and consequently also their cleaning. The provision of this ball bearing introduces, however, a departmental difficulty, inasmuch as it will be at the cost of the permanent way department, which gains nothing by the change, and a reduction is made in the operating department's expenses without any initial outlay.

Notes and Memoranda.

A DIESEL engine of 2900 horse-power which is to be fitted in an American cargo ship recently completed a non-stop trial run of thirty days.

IT is suggested that the two 10,000-ton cruisers, which are to be built for the United States Navy, should be equipped with machinery working at a pressure of 700 lb. per square inch.

THE electric power transmission line from Yallourn to Corowa, Australia, was put in service early in February. It is worked at a pressure of 22,000 volts and is 277 miles long, which makes it the longest transmission line outside America.

A NEW form of thermometer for measuring high temperatures has been brought out by the General Electric Company. It comprises a quartz stem and bulb, filled with gallium, as the expanding liquid, and is capable of withstanding temperatures above 1000 deg. Cent.

A SYSTEM of steam heating for chemical processes, which is receiving considerable attention in Germany, employs wrought iron pipes embedded in cast iron, in the place of the usual jacket. The pipes are cast in place in the walls of the pan and all joints are welded. The scheme has the advantages of providing an evenly distributed heat, eliminating large bolted joints, and enabling high pressures to be adopted safely.

ALTHOUGH the United States has been producing crude oil since 1859, and up to January 1st of this year has produced approximately 8662 million barrels, it is interesting to note that during the past ten years the production has amounted to 58 per cent. of the total, and during the past five years there has been produced 37 per cent. of all the oil that has been taken from the ground since the first well was drilled.

IT is proposed to construct a cantilever bridge to connect Rhode Island with the American mainland by a crossing at the entrance to Mount Hope Bay. The main span will be of 1200ft., but the most striking feature of the design is the suggestion to employ four top chords, and only two bottom chords, tied together in the form of two triangular structures. The arrangement, it is said, will economise in the flooring supports.

THE support of the Federation of British Industries has been secured for the movement to organise a British Section at the Philadelphia Exhibition next June, in connection with which an advisory committee has been formed under the chairmanship of Sir Lawrence Weaver, late director of United Kingdom exhibits at Wembley. The Exhibition is being held to commemorate the one hundred and fiftieth anniversary of American Independence, and, covering 1000 acres, will be many times bigger than the British Empire Exhibition.

IN the course of a lecture on paint-spraying, before the Junior Institution of Engineers, Mr. F. E. Webb recently said that from the preservation point of view, the application of paint by means of a brush did not attain its object nearly so well as paint sprayed on under pressure; the former merely gave a surface coating, while the latter method caused the paint to penetrate the pores of both wood and mild steel, as could be ascertained by microscopical examination, besides penetrating to crevices and difficult corners not easily reached by a brush. The other advantages claimed were ease and rapidity of execution, and a far more perfect surface than that attained by the brush method.

A STUDY of the mechanism of corrosion and the factors effective in its control in steam power plant operation is being conducted by the Bureau of Mines, Department of Commerce, at its Pittsburg, Pa., experiment station. The purpose of this investigation is to obtain data on the amount of hydrogen concentration that should be maintained in the boiler water in order to reduce corrosion to a negligible proportion. In economiser tubes and feed lines, especially, dissolved oxygen in the water causes a great deal of corrosion. Elimination of dissolved oxygen can be partly effected by de-aeration, but this does not wholly remove the oxygen. If the hydroxyl concentration can be controlled to suit the conditions, it can be utilised to control the oxygen.

AT the annual meeting of the London Branch of the Association of Mining Electrical Engineers, which was held at Chislet Colliery, Kent, Mr. C. Dawson, chief electrician at the colliery, gave particulars of an occurrence of a static electrical charge on their boiler plant. It appears that the boiler foreman reported that on operating the main stop valve on one of the boilers he had received an electric shock. It was discovered that the area for several feet around the stop valve was charged electricaly at a high potential. With all cables in the vicinity switched off a ½in. spark could be obtained by a person standing on a dry plank or boiler covering and holding a screw-driver near the main valve. Eventually, after exhaustive investigation, it was found that there was a minute hole in the auxiliary steam range, which was blowing a very fine jet of steam towards the main stop valve.

DURING the second half of 1925 there were, according to the *Chemical Trade Journal*, 67 factories producing cellulose lacquers in the United States, the total output during the period being over 26,000,000 litres. American production of butyl alcohol grew from 2,000,000 kilos. in 1923 to 6,400,000 kilos. in 1924, and the estimated output for 1925 is 8,000,000 kilos. Butyl acetate output in 1925 totalled 4,500,000 kilos. Amyl acetate as a solvent for the lacquers has been largely displaced in America by butyl alcohol and butyl acetate, though ethyl acetate is rapidly growing in importance as a solvent, in addition to butyl propionate, butyl phthalate, and amyl phthalate. American production of carbon tetrachloride increased from 6,500,000 kilos. in 1924 to 7,600,000 kilos. in 1925. The Bethlehem Chemical Company, with a capital of a million dollars, has started a plant at Wilmington, Del., to make lacquers. The output is estimated at 60,000 gallons per month. Five or six German varnish makers are beginning to produce spray lacquers with a cellulose base.

Miscellanea.

WORK has been started on the 300ft. extension of the North Pier at Durban, and it is expected that the operations will occupy four years.

A NEW coal pit, to reach the Peacock vein at a depth of 1800ft., is to be sunk by Guest, Keen and Nettlefolds, at Lower Cwmgorse, Swansea Valley.

THE Newcastle-on-Tyne Chamber of Commerce is calling a meeting after Easter to discuss the possibility of organising a local section of the British Industries Fair, on the same lines as that at Birmingham.

THE Ontario Hydro-Electric Commission is conferring with the municipalities concerned on a proposal to construct a high-speed radial railway from Toronto to Hamilton at a cost of 11,000,000 dollars.

IT is reported from Prague that the Krizik Company of Prague, the Bratislava Cable Works and the Kablo Company of Kladno, are forming a joint stock company for the manufacture of long-distance cables.

WHAT is claimed as a record was scored by the coal mines of British Columbia in 1925 in the matter of fatalities in this industry, according to figures announced by the Minister of Mines, the death-rate per 1,000,000 tons of coal mined having been only 2·4 per cent.

IT is proposed to construct seven new bridges over the Vaal and Orange Rivers, at a cost of £150,000. The sites recommended for bridges on the Vaal are Christiana, Greylingsdrift, Scandinavia Drift, Villiers and Klerksdorp. For the Orange the sites are Roberts Drift and Zastron.

THE new bridge over the Umgeni River, Natal, to carry the North Coast Railway, has been completed and put in commission. It replaces the wooden trestle which was carried away by flood in 1917, and comprises nine 100ft. spans and two 60ft. spans. The foundations were carried down 157ft. below average summer water level.

ONE of the largest consignments of cement exported from the United Kingdom since the war has been shipped to Miami (Florida) by the Associated Portland Cement Manufacturers from their Swanscombe Works on the Thames. The consignment, carried by the steamship Nidaholm, consisted of 76,446 sacks of British Portland cement and 100 casks of Ferrocrete, the rapid-hardening cement.

THE Turkish National Assembly has voted a credit of T£18,000,000, to be spread over four years, for the development of the Turkish coal and iron industry and the construction of smelting plant. It is proposed to engage three foreign experts to assist in the work. The Assembly also voted a credit of T£14,000,000 for the construction of a railway from Kaisarieh—160 miles East of Angora—to Oloukishla.

IT is reported that the negotiations which have been proceeding in Paris between British, Belgian, French and German steel interests on the subject of forming a rails trust have resulted in a provisional understanding being reached, without, however, any signatures being affixed to a definite agreement. Negotiations, we gather, have been postponed until later this month, but neither the place nor the date of the meeting have been fixed.

A CABLEGRAM from Sydney states that the New South Wales Cabinet has accepted the recommendation of its sub-committee that a 15,000-ton floating dock shall be constructed at Walsh Island Dockyard, Newcastle, at a cost of approximately £435,000. This decision will entitle the New South Wales Government to a Commonwealth subsidy of £135,000, on condition that the dock is handed over to the Commonwealth Government in time of war or other emergency.

IT is reported by the Manchester Steam Users' Association that the general work of the Association was steadily carried on during the year, the total number of examinations made being 24,313. Of these 11,315 were "Entire" and "Internal," with the boilers at rest and prepared. In its report for 1924 reference was made by the Association to the new Factory Bill which had been introduced to Parliament. In July a deputation of boiler-owners waited upon the Home Secretary and shortly afterwards the Bill was allowed to drop, but it is possible it may be revived in the near future in its original or in an altered form. In that event members may rest assured that the matter will again receive the Committee's earnest attention.

IN view of the provisional agreement for special tubes—socket and boring tubes—between the Germano-Czech tube combination and the French tube rolling works, it is intended to arrive at an understanding regarding prices for other sorts of tubes. It is reported that negotiations to that end are already proceeding, but that so far they have led to no result. The opinion is held by some that success will only attend the negotiations when the French works have first agreed among themselves. There exists in France a tube syndicate, which, however, is only concerned with home sales, the works themselves arranging those to foreign countries, but not all the works belong to this syndicate. Whether the agreement between Germany and France for the special tubes mentioned above, which expires at the end of June next, will be prolonged is uncertain.

THE first two 10,000-ton post-treaty cruisers to be built for the United States Navy, the Salt Lake City and Pensacola, may, it is reported from Washington, represent as radical a departure from normal marine engineering practice as did the adoption of electric drive for all recent battleships, and for the aeroplane carriers Lexington and Saratoga. As designed by the Navy Department, the two vessels were to be propelled by geared turbines, which, to save engine weight, were to work with steam under a 700 lb. pressure as compared with 300 or less now generally used afloat. The increase in pressure would, of course, carry with it the necessity of re-designing boilers, all steam lines, packing glands and other parts of the engine plant that must bear the greatly increased stresses and temperatures. The final decision will, however, depend on the proposals made by prospective tenderers for construction of the Salt Lake City, who are preparing to submit alternative proposals based on normal pressure steam plants of their own design.

REINFORCED CONCRETE RETAINING WALLS FOR A ROADWAY IN INDIA

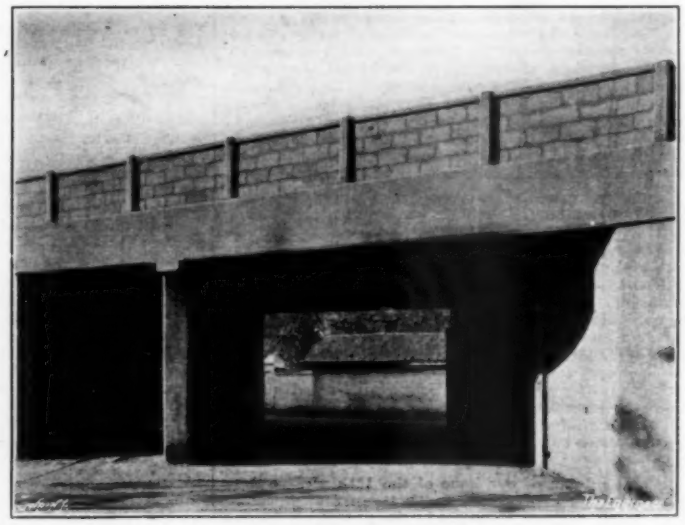
J. C. GAMMON, LTD., BOMBAY, ENGINEERS

(*For description see page* 390)

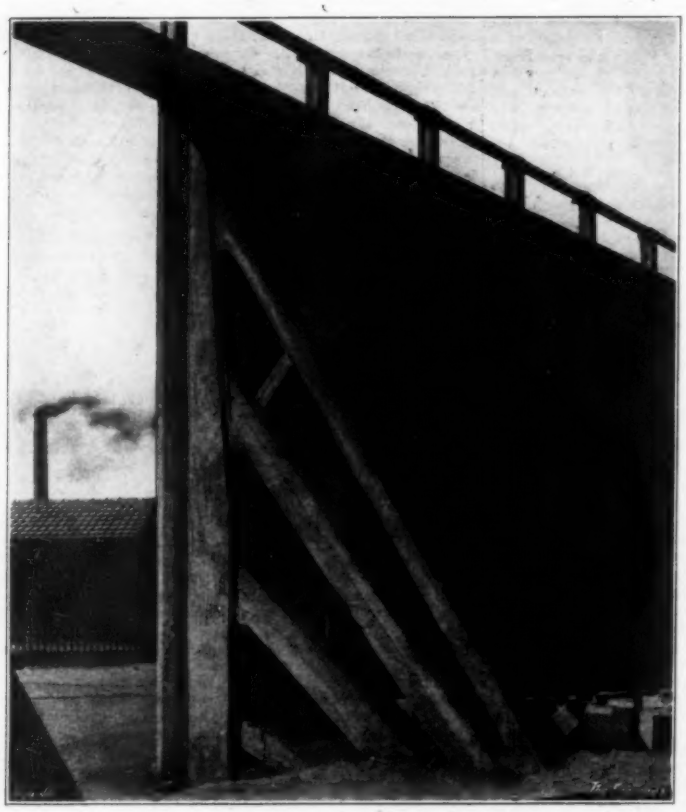
SPACE TO BE FILLED IN TO CARRY ROADWAY

RAILWAY WITH RETAINING WALL BEYOND

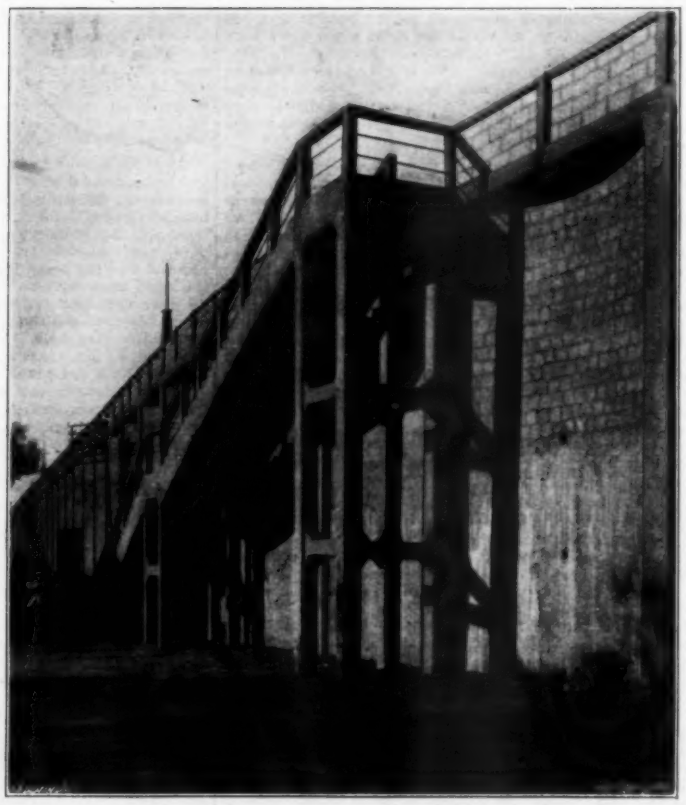
DIAGONAL TIES SECURING WALLS TO ANCHOR BEAMS



PASSAGE BELOW ROADWAY



OPENING THROUGH EXTERNAL WALL



ACCESS STAIRWAY TO ROADWAY

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The Engineer

BUENOS AIRES.—MITCHELL'S BOOK STORE, 576, Cangallo.
CHINA.—KELLY AND WALSH, Limited, Shanghai and Hong Kong.
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FRANCE.—BOYVEAU AND CHEVILLET, Rue de la Banque, Paris.
CHAPELOT AND CIE., 136, Bld. St. Germain, Paris.
BELGIUM.—W. H. SMITH AND SON, 78/80, Rue du Marché-aux-Herbes, Bruxelles, and 44, Rue Joseph II., Ostend.
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Contents.

THE ENGINEER, April 2nd, 1926.

	PAGE
A SEVEN-DAY JOURNAL	373
TRADITIONAL ARCHITECTURAL FORMS AND THEIR STRUCTURAL EFFICIENCY. (Illus.)	374
THE REPORT ON THE COAL INDUSTRY	375
HYDRAULIC DEVELOPMENTS OF THE MIDI RAILWAY IN THE OSSAU VALLEY. (Illus.)	376
INSTITUTION OF NAVAL ARCHITECTS. No. II.	379
A NEW GERMAN STEEL AND COAL TRUST	382
THE M.A.N. DOUBLE-ACTING MARINE OIL ENGINE. (Illus.)	382
BOOKS OF REFERENCE	384
LETTERS TO THE EDITOR—	
The Choice of Steel for Engineering Work	384
Electricity Supply	384
SUPER-ACCURACY	384
INSTITUTION OF ELECTRICAL ENGINEERS	384
RAILWAY MATTERS	385
NOTES AND MEMORANDA	385
MISCELLANEA	385
LEADING ARTICLES—	
The Comparison of Power Stations	387
A Foreigner on British Railways	388
OBITUARY—	
Francis Hird	388
Henry Folland	388
INDIAN IRRIGATION: 1921–1924. No. I.	388
LITERATURE	389
SIXTY YEARS AGO	389
REINFORCED CONCRETE RETAINING WALLS IN INDIA. (Illus.)	390
INDUSTRY AND TRADE	390
TEMPERATURE VARIATION AND HEAT STRESSES IN DIESEL ENGINES. (Illus.)	391
THE GARRATT LOCOMOTIVE	392
WHAT IS SEA SPEED?	392
THE ROYAL INSTITUTION OF GREAT BRITAIN	393
PERSONAL AND BUSINESS ANNOUNCEMENTS	393
THE HIGH EFFICIENCY OIL ENGINE. (Illus.)	394
PROVINCIAL LETTERS—	
The Midlands and Staffordshire	395
Lancashire	395
Sheffield	396
North of England	397
Scotland	397
Wales and Adjoining Counties	397
CURRENT PRICES FOR METALS AND FUELS	398
FRENCH ENGINEERING NOTES	399
BRITISH PATENT SPECIFICATIONS. (Illus.)	399
FORTHCOMING ENGAGEMENTS	400

THE ENGINEER.

APRIL 2, 1926.

The Comparison of Power Stations.

NOBODY can discuss power station matters very long before the word "efficiency" is mentioned. The form in which electricity is generated may be slightly different in different stations, but the quality is always the same, so that the main basis of comparison between one station and another is the efficiency with which electricity is produced. The universal agreement that efficiency is a thing to be striven for tends to obscure the various meanings which are attached to the word. The business man would maintain, with a fair show of reason, that that station was the most efficient which could deliver power on the feeders at the lowest average cost. He would argue that the one and only object of a power station was to produce cheap power, so that efficiency was properly measured by the number of saleable kilowatt-hours obtained in return for the consumption of a sovereign. No good engineer will deprecate that point of view. It is indeed the foundation of sound engineering, but since efficiency in the commercial sense is so closely bound up with efficiency in a more technical sense, the desire to increase technical efficiency is ever uppermost in the mind of the engineer. Progress in this direction can only be noted by having some agreed definition of efficiency in the engineering sense, and some numerical scale on which it can be measured. It is here that the difficulty arises. The scale ought to be such a one that a condition of perfection would be represented by 100 per cent., if the numbers representing actual attainments are to be truly significant. The ordinary way of expressing the efficiency of a power station is to state the percentage of the heat units in the fuel which have been turned into useful electrical energy. An efficiency of 20 per cent., on this basis, would be considered exceptionally good, and hence we continually meet with lamentations in the uninstructed Press concerning the terrible waste of fuel which figures of this order suggest. The fact is, of course, that our scale is a misleading one. There is no steam power station in the world which could have an efficiency of more than about 60 per cent., even if its boilers, turbines and generators were perfect in every way. The fault is not in the station or in its equipment, but in the use of an impossible standard of comparison. An efficiency of 100 per cent. would only be realised in an ideally perfect station with condensers maintained at the absolute zero of temperature, and under such hypothetical conditions all perfect stations would have the same efficiency whatever the pressure and temperature of their steam.

It is the custom among some engineers to compare the performances of power stations on the basis of the actual number of British thermal units required to produce a kilowatt-hour. Instead of saying that one station had a thermal efficiency of 20 per cent. and another had an efficiency of 19 per cent., the first would be said to consume 17,060 B.Th.U. per kilowatt-hour, against a consumption of 17,958 B.Th.U. per kilowatt-hour for the second. This plan avoids the inference of unduly low efficiency which the figures of thermal efficiency expressed as percentages are liable to produce, but it conveys no idea as to the degree with which perfection has been approached. It has also the possible disadvantage that the highest figures correspond to the lowest efficiencies. There is, in fact, little or nothing to choose between the two methods, as they both, whether obviously or not, contain the implication that if the plant were perfect a kilowatt-hour could be produced for the expenditure of 3412 B.Th.U. in the fuel. How, then, are we to avoid this difficulty? It is clearly misleading to take as our standard of efficiency a plant which would produce a kilowatt-hour for an expenditure of heat far less than would be required by any plant which Nature would permit us to construct or even to approach. If our upper and lower temperature limits were definitely fixed, either by natural conditions or by the properties of materials, it would be easy to determine a heat consumption per kilowatt-hour with which the performances of all steam plants could be compared. With steam at 1000 deg. Fah., for example, and a condenser at freezing temperature a perfect plant would require 5145 B.Th.U. in the fuel for every kilowatt-hour produced. As an arbitrary standard of efficiency such a heat consumption might serve the purpose for the time being, and on such a basis a station now showing 20 per cent. thermal efficiency would be credited with an efficiency of about 30 per cent. This would certainly raise the original figure by some 50 per cent., but the new value would, nevertheless, be so far below the new standard that few people would consider the new basis worth adopting. It would, moreover, have nothing fundamental to commend it. The proposed upper limit of 1000 deg. Fah. is already in sight, and with the development of structural materials it may be surpassed. The fact is that any suggestion to fix upper and lower temperature limits with a view to procuring a standard basis of comparison for power station performances would fall to the ground owing to the impossibility of securing agreement as to what those limits should be. A power station could be said to be perfect if it turned into electricity, not all the heat in the coal, but all the heat which was theoretically convertible into work, as no station could do better than that. Hence the extent to which any station succeeded in utilising this available heat, as distinguished from the total heat in the fuel, might be taken as the efficiency of its performance. Such a figure would correspond to the "efficiency ratio" used in connection with steam turbines. It would indicate how well the station was doing within the limits of temperature and the cycle of operations which had been assigned to it. For any given station it would constitute a fair measure of the merit of the performance of the plant, and the relative merits of different stations, so far as performance was concerned might be compared on this basis. If two stations both put 80 per cent. of the heat of the coal into the steam, and both turned 50 per cent. of the available heat of the steam into electricity, they might be said to be doing equally well, from the operating point of view. But if one was using steam at 300 lb. pressure with a 29in. vacuum, while the other had a pressure of 200 lb. only, with a 28in. vacuum, the quantities of available heat would be very different. Assuming both stations to work on the Rankine cycle and to have a steam temperature of 700 deg. Fah., the station with the higher pressure and better vacuum would have about 470 B.Th.U. of available heat per pound of steam as against about 413 B.Th.U. in the case of the other. The former would therefore be producing a kilowatt-hour for about 14.5 lb. of steam, or about 24,000 B.Th.U. in the furnaces, whereas the latter would require about 16.5 lb. of steam and 27,000 B.Th.U. in the furnaces for the same output. Had either of the stations been working on some other cycle than the Rankine, the relative efficiencies would have been different again.

It is clear, therefore, that to make a proper comparison between different plants it is not sufficient to know how each would compare with an ideally perfect plant working under the same conditions, but also how the conditions themselves compare with each other. The conditions as to temperature, pressure, cycle, &c., are determined by the designer and they are his contribution to the merits of the performance of

the station. To secure the best possible performance within the limitations imposed by these conditions is the task of the operating engineer. The latter should be judged only by the measure of his success in making the best of the plant he has got. For every set of conditions there is an ideal performance. The designer says, in effect, "I provide you with such steam pressures, &c., as should theoretically enable you to turn, say, 35 per cent. of the heat of the coal into electrical energy. The best, therefore, that an ideal plant could do under these conditions would be to produce a kilowatt-hour for 9750 B.Th.U. in the coal, and you, and the manufacturers of the machinery, will be judged by the measure of your approach to this ideal heat consumption." It is this limiting figure for every particular plant which deserves special attention. Once calculated, it remains constant so long as the heat cycle is unchanged. It is not only a figure of merit for the design, from a thermodynamic point of view, but, although it can, of course, never be attained, it is a more practical objective to aim at in operating than the 100 per cent. with which station performances are usually compared. There is no sense in saying, as we generally do, that a station is turning into work 20 per cent. or so of some quantity of heat, of which we are forbidden by Nature to use more than about half in any case. The statement is deceptive, and it would seem much preferable to make our comparison only with the heat which could theoretically be utilised in any particular circumstances. Supposing, for example, that the ideal heat consumption of a station were, say, 9750 B.Th.U. per kilowatt-hour. If, on the ordinary basis the thermal efficiency was 20 per cent., it would become 57.2 per cent. on the basis of the heat really available, and a figure of 100 per cent. would correspond with ideally perfect material and operation, instead of, as now, denoting a hopeless impossibility.

A Foreigner on British Railways.

There is no nation more self-critical than the British, and no part of that nation more addicted to that rather dangerous practice than the United Kingdom. It was not always so. In our palmy days we had a confidence in ourselves which made for self-respect, supported us in the face of great difficulties, and led us to success where others would have failed. In emergency we can evoke that spirit still, and despite constant carping, we "muddle through," as people say, even when success seems impossible. But in the ordinary way we have allowed highbrows to convince us that we have nothing of which to be particularly proud, and that it is more fitting that we should hide our heads than that we should vaunt our prowess. We continually contrast ourselves to our own disadvantage with other nations, and we pay more attention to our failures than to our successes. In that respect we are like the *malade imaginaire*, who accentuates the small complaints that he has until they become great, and fashions greater illnesses out of a self-pitying imagination. Far better would it be for us to practise the principles of Coué than continually to nag our weary nerves with odious comparisons between ourselves and others. The man who fights with confidence is thrice armed, he who fights with an initial disbelief in himself is vulnerable at every point.

It is well for us, then, that we should see ourselves occasionally as others see us, not from the accepted point of view that our faults will then be exhibited for our moral good, but that we may regain some of that self-confidence which is such an important factor in success. It is for this reason that we hope very many of our readers have studied with care the charming series of articles on British railways which an eminent continental engineer has just concluded in our columns. Of two things Great Britain is justly proud. If we must place in the first position all that concerns ships, the second honour must assuredly be given to locomotives and railways. But neither one nor the other escapes that class of petulant criticism to which we have already referred. It may be said, indeed, that the standard which we set for our railways is so high that we ourselves see faults which others would never see. We grumble at and we criticise slight departures from our customary comfort and convenience where others praise the very standard which we depreciate. The author of the articles to which we have referred is no ordinary observer. He has not based his opinions, so candidly and kindly expressed, after no more than a hurried visit to our shores. As well acquainted with the railways of the United Kingdom as he is with the railways of the whole of Europe, he writes as one who has travelled on them for many years, and is able to make a just comparison between what he has found on the Continent and in our little island. Moreover, his knowledge of railways is of a technical character, and he is able to speak as an expert on locomotives, on rolling stock and on general railway management. Hence he presents a picture of British railways which is really worthy of consideration. Our pessimists, who would rather dwell upon our faults than upon our virtues, will say that he flatters us, that he gives too much praise to our admirably kept roads, that he admires too greatly our homogeneous rolling stock, that he sees in our locomotives—machines which have been designed for a special purpose and fit that purpose well—more than they merit, that our organisation—characteristed as it is by freedom from State control which burdens continental systems—makes an undue appeal to him, and that he is impressed overmuch by the British phlegm which results in the manipulation of difficult railway movements with a lack of noise and fuss. But whatever the critics may say there is, we contend, a fairer aspect. The author had no intention of flattering us. His purpose was to present a true picture of British railways in the first quarter of the twentieth century, and we are confident that in years to come, when, perchance, railways are forgotten, historians will turn to his articles just as now we turn to the reports which foreign observers made upon our railways in the early days of their existence. Of course, our author finds some matters for criticism, but in handling them he shows a wisdom and a knowledge which is frequently lacking in the home critics. He recognises what is so often forgotten, that the British railways are made for Great Britain, a little land of short distances, and that it would be mere folly to attempt to introduce methods and materials which suit the conditions of larger countries. Furthermore, he sees that we are continually progressing towards something better, and that we continually maintain that status of our railways which commands the respect of visitors. He knows, being an expert, that improvements cannot be effected in a vast system of railways in a day, but that they have to be made step by step, and with infinite care not to cause dislocation by unwise hastiness.

We shall not be so hardy as to declare that the British railway system is perfect, nor will we for one moment deny that it can profit by intelligent criticism. But by comparison with the railway systems of other countries we assert without hesitation that it takes the first place. The visitor to other lands who has not the time or the opportunity to study traffic conditions as carefully as our author has done forms his conclusions too frequently on wrong bases. The long-distance trains of France, for example, leave nothing to be desired, but it is unfair for the traveller who has just come through by a crack train from the Riviera to compare the Southern service which brings him from the coast to London unfavourably with it. Again, it shows a lack of perspective to set the vast mineral services of America against the relatively small services of this country. One must look behind the scenes to find the whole truth. When that is done it is discovered, as our author has pointed out, that in no country in the world have railways attained such a general high excellence as in this. They owe that excellence in no small degree to the fact that Government has never exercised more than a supervisory control over them, and that they have been developed by individual enterprise and encouraged by the play of reasonable competition. The author of the articles, writing with an intimate knowledge of the effect of State control, gives us a clear picture of its defects, and gives us encouragement to oppose the greatest danger which British railways have to fear—Nationalisation.

Obituary.

FRANCIS HIRD.

We regret to have to put on record the death of Mr. Francis Hird, who was managing director of Siemens Brothers and Co., Ltd., the Siemens and English Electric Lamp Company, Ltd., and Caxton Electric Developments, Ltd., and a director of the Siemens and General Electric Railway Signal Company, Ltd., Elliott Brothers (London), Ltd., the Enfield Cable Works, Ltd., the St. Helens Cable and Rubber Company, Ltd., and the Fixed Price Light Company, Ltd.

Mr. Hird was born—of British parentage—in Paris in 1868. He came to England in early childhood, and was educated at the Bradford Grammar School, from which he secured a Natural Sciences Exhibition at Trinity College, Cambridge, and studied under Professor J. J. Thomson at the Cavendish Laboratory. He obtained a First Class in the Natural Sciences Tripos, and took his degree of B.A. in 1887 at the rather unusually early age of nineteen.

In 1889 he joined the staff of Siemens Brothers and Co., Ltd., and after a few years became chief dynamo designer to that company. In due course, after having gained some commercial experience, he became head of the electric light and power department of Siemens Brothers.

In connection with the various activities in electrical development proceeding at that time, it may be mentioned that Mr. Hird took a considerable personal share in the design and construction of the original equipment of the Waterloo and City Railway.

For some time he was works manager of Siemens Brothers Dynamo Works, Ltd., at Stafford, but subsequently returned to Siemens Brothers and Co., Ltd., in order to take charge of the apparatus department of that company and to develop its light current work generally. In this connection he instituted the firm's telephone department, and thus enabled Siemens Brothers and Co. to be among the first to introduce practical automatic telephone exchanges in this country.

Mr. Hird was appointed general manager of Siemens Brothers and Co., Ltd., in 1922, and managing director in April, 1925. He was in his fifty-ninth year.

HENRY FOLLAND.

News was received in this country on Thursday of last week that the death had taken place in Egypt of Mr. Henry Folland, of Llwynderw, Blackpill, Swansea, who was a leading figure in the tin-plate industry of South Wales.

Mr. Folland, who was forty-seven years of age, rose from very humble circumstances to the top of the tree. He first obtained employment at the Melyn Tinworks, Neath, and afterwards went to the Raven Tin-plate Works, Glanamman, where promotion came to him rapidly, and on the death of the manager he succeeded to that position, later joining the directorate of the undertaking. He subsequently became the joint purchaser of the Grovesend Works, and secured a controlling interest in the firm. Other developments followed until he became the head of what was known as the "Folland Group," which included the Grovesend Works, the Gorseinon Works, the Amman, Raven, Dynevor, Cambria, Whitford, Hendy and other works.

Mr. Folland was also interested in colliery enterprises, and in 1920 he was concerned in one of the biggest transactions in the history of the South Wales steel and tin-plate trade, when the Folland Works were amalgamated with Richard Thomas and Co., of Swansea and Llanelly. He was Vice-president of the Welsh Tin-plate and South Wales Siemens Steel Associations.

Indian Irrigation: 1921-1924.

No. I.

The triennial review of irrigation in India, dealing with the years 1921–1924, has recently been published by the Government of India. These periodical reports furnish matter of absorbing interest to officers, active and retired, of the Indian public services, and provide irrigation engineers generally with useful information as to factors influencing irrigation. The present report is also a record of additions made to water storage, extensions of canals, other works of improvement, and projects in hand, sanctioned or being studied. The subject matter is mostly presented in the form of a series of reports, each relating to a province, but there is also a summary of the monsoon conditions of the three years, as affecting the country generally, and tables giving the principal figures of the irrigation finance of the period.

For the purpose of the present summary, and for the convenience of readers who may be interested in some aspects only of Indian irrigation, matters relating to specific subjects and dealt with in the provincial reports will here be grouped under their subject headings. The monsoons will be very briefly described, but details of that of 1924 may be found in The Engineer, March 13th, 1925. The figures relating to finance must be taken as non-officially presented, and the full statements given in the report itself should be referred to before any important deductions are made from them.

The Monsoons.

In the first of the three years the monsoon broke at or before the usual time; the amount of rainfall over the country as a whole was nearly normal, its distribution unequal. There was deficiency over the greater part of the peninsula, excess of about 20 per cent. in the United Provinces, the North-West Frontier Province, Gujerat and South-East Madras; excess of about 40 per cent. in Baluchistan and South-West Punjab, and double the usual fall in Sind.

The next year, described in the report as 1922–1923, the rains broke at the usual times, and throughout the season the currents were, on the whole, vigorous, if fitful. Averaged over the plains of India, the rainfall was 5 per cent. in excess. It was in excess in the tract extending from eastern and northern Punjab to Orissa and Bengal, deficient over the peninsula, except the west coast, and in the region of North-West India.

The 1923–1924 monsoon broke somewhat after the usual date. In the early weeks it was vigorous in Burma and Assam, and fairly so in Bengal, but weak in North-West India. Not till the beginning of July did it penetrate effectively into the interior of the country, bringing well-distributed rains until the 23rd. Averaged over the plains as a whole, the fall was 8 per cent. above the normal, and it was well distributed over most of the country.

The rainfall of the three years may be regarded as favourable. It may be compared with that of the preceding triennium, in which one good year followed and was followed by a lean year. In 1918–19 there was an early monsoon, but it faded away, and there was no important improvement until the middle of August. The average deficiency throughout the plains was greater than in any year since 1877. In 1919–1920, an early but fitful beginning was followed by intense heat, and by mid-July there was effective penetration into North-West India, and thereafter copious rains over most of the country, about 5 per cent. in excess of the normal. In 1920–1921 the monsoon broke at the usual time, but was unequally distributed. A break in June was followed by a fairly active current in July, becoming weak in August, and in North-West India there was little rain after the first week in September. In all the major irrigation provinces, except Madras, the rainfall was much in defect; 13 per cent. in the United Provinces, 29 per cent. in Bombay, 33 per cent. in the Punjab, and 83 per cent. in Sind. Such were the conditions, then, in the year preceding the triennium now under consideration.

Areas Irrigated, Classification.

The introduction of the Reforms Scheme led to an important change in the general structure of the Accounts of the Government of India. Irrigation works were previously divided into two main classes, Major and Minor works. The former were subdivided into:—(*a*) Productive Works; (*b*) Protective Works; and the latter into (i.) works for which both capital and revenue accounts were kept; (ii.) works for which only revenue accounts were kept; (iii.) works for which neither capital nor revenue accounts were kept. The present classification is under two heads only—(*a*) Productive and (*b*) Unproductive.

The area irrigated by Government irrigation works was 10¼ million acres in 1878-1879 and 19¼ millions at the beginning of the present century. The average areas irrigated in the last three trienniums were in millions of acres:—1915–1918, 25¾; 1918–1921, 26¾; 1921–1924, 27¼. Taking the last six years, the area in 1918–1919 was 25·15; it increased by 2·99 to 28·14 in 1919–1920; decreased by 1·14 to 27·00 in 1920–1921; increased to 27·58 in 1921–1922; increased by 0·72 to 28·30 in 1922–1923, and decreased to 26·54 in 1923–1924. Thus, while the greatest difference between one year and the next was 2·99, the largest algebraical sum of two consecutive differences was 1·85 and the smallest 0·56, there being four such consecutive differences in the figures cited.

The totals are made up as follows:—1921–1922, productive works areas, 19·195 millions of acres; unproductive, 3·541; non-capital works, 4·842. 1922–1923, productive, 19·892; unproductive, 3·250; non-capital, 5·160. 1923–1924, productive, 19·870; unproductive, 2·535; non-capital, 4·133. Triennium, productive, 19·652; unproductive, 3·109; non-capital, 4·712. Total, 27·47 million acres.

Areas Irrigated in the Several Provinces.

In the preceding triennium, if we start from the average areas irrigated in the triennium 1915–1918, and thereafter take the changes from year to year, the three differences are in no case three decreases, and in only one case are they three increases, Bombay Deccan. In five provinces, two are increases and one a decrease, and in six provinces two are decreases and one an increase. In the triennium 1921–1924, starting from the areas irrigated in 1920–1921, the differences year by year show:—All three increases in Burma; all three decreases in Bengal and in the United Provinces; in six provinces two increases and one decrease; and in three provinces two decreases and one increase. These figures are of considerable importance as suggesting a certain stability as regards irrigation in the country as a whole.

Reasons for Increases and Decreases in the Areas Irrigated.

The reasons for the increase or decrease in the average areas irrigated in the triennium 1921–1924, or any year of the three, as compared with those irrigated in the previous triennium or the previous year, are very instructive. The steady progress made must, of course, preclude any such conception as an average taken over a long period.

Taking first the increases:—

Sind.—A good inundation in 1921 and an exceptionally good inundation in 1922.

The Punjab.—Favourable seasons, and the steady development of the canal system.

Burma.—Expansion of the Yeu Canal.

Central Provinces.—Probably due to the satisfactory working of the long-term agreement system.

North-West Frontier Province.—A light rainfall, and the high price of grain.

Reasons for decreases:—

Madras.—An ill-distributed rainfall in 1923–1924. Damage to tanks and irrigation works by a cyclone and by excessive rains.

Deccan and Gujerat.—A deficient rainfall in 1923, especially in North Gujerat.

Bengal.—On the Midnapur Canal some cultivators refused to renew their leases.

United Provinces.—Low river supplies and timely winter rains.

Bihar and Orissa.—Leases not renewed, (*a*) because of good rains, (*b*) possibly also because rates were increased.

North-West Frontier Province, 1923–1924.—Good rains, drop in grain prices, plague.

We find from these cases that good rains indirectly increased the area under irrigation in Sind; timely rains in the United Provinces decreased the irrigated area, as did good rains in Bihar and Orissa, and in the North-West Frontier Province, where, however, a light rainfall in another year led to an increase in the irrigated area. Excessive rains indirectly decreased the irrigated area in Madras in one year; while in another year the area irrigated in that province was reduced by an ill-distributed rainfall. A deficient rainfall caused a decrease in the Punjab, Deccan and Gujerat and indirectly in the United Provinces, in combination, in that case, with a favourable local rainfall.

Administrative conditions seem to have contributed to or caused an increase in the United Provinces and a decrease in Bengal and possibly in Bihar and Orissa. The development of canal systems led to increases in the Punjab and Burma, and doubtless to some extent in other provinces. Other factors noted include grain prices and plague.

Few would suppose that, apart from the extension of canals, the area under cultivation by irrigation depends directly upon the rainfall, but many engineers who are not conversant with Indian conditions may not realise the extent to which the particular significance of rainfall may vary with changes of distribution, amount and date. The effects produced vary according as the area is irrigated from a perennial river, from large storage reservoirs or from many small "tanks."

Works Completed in the Triennium.

In Madras Presidency, the Mopad Project was completed for an outlay of 22·90 lakhs, and the Toladur Project for an outlay of 25·89 lakhs. The latter has for its object the utilisation of the flood waters of the Vellar River for the irrigation of 25,000 acres of unprotected area. Six smaller works cost altogether 22·88 lakhs, and include the Siddapur tank, the Bhavanassi tank and the Muniyeru Project. They will irrigate over 13,000 acres. In Bombay Presidency the Girna River works (Deccan and Gujerat) were completed, and in Sind improvements to the headworks of the Jamrao Canal and a weir across the Nara below the head of the Khipro Canal. In the United Provinces the Kho weir was completed, 1921–1922; and the Kitham reservoir for supplementing the water supply of Agra. In the Punjab the remodelling of the headworks of the Lower Jhelum Canal and the construction of a subsidiary weir at Tajawala, the headworks of the Western and Eastern Jumna canals, were completed. In Burma the area protected by embankments was increased by nearly 67,000 acres, to a total of 908,776 acres. In the Central Provinces nine works were completed, the tanks, Jamunia, Kattanjheri, Bodalkassa, Chorkamara, Ghorajheri, Naleswar, and Borina; and the Wainganga and Tandula canals. In 1923 the Maramasili reservoir was completed. In connection with this work a syphon spillway has been built, consisting of thirty-four syphons, each 8ft. by 8ft., of reinforced concrete. This is the first of its kind to be erected in India on a large scale.

Literature.

SHORT NOTICES.

Materials Testing Theory and Practice. By I. H. Cowdrey and R. G. Adams. London: Chapman and Hall, Ltd.; New York: John Wiley and Sons. Price 7s. 6d. net.—The authors of this book, both members of the staff of the Massachusetts Institute of Technology, have sought to provide a work to accompany a laboratory course in the study of materials under stress, and have endeavoured to deal with general principles rather than to detail any particular set of tests or experiments. So far as we can judge, their efforts to subordinate the peculiarities and characteristics of different forms of testing machines and equipment to the action of the materials during the tests will be found by American students to be successful and satisfactory. In this country, while some useful information will no doubt be obtained from the book, its value will, we think, be restricted by the fact that it reflects American practice and draws at frequent intervals for data and information upon the publications of the American Society for Testing Materials and upon the thesis files of the Massachusetts Institute's mechanical engineering department. The reader on this side of the Atlantic runs some risk of being misled unless he is already aware of the different ideas as to standards and testing practice generally prevailing on the other side.

Pyrometers. By E. Griffiths. London: Sir Isaac Pitman and Sons. 1926. 7s. 6d.—A very handy and informative little volume for the practical man engaged in work which requires the determination of temperatures, whether they be below or above zero. The various means of measuring temperatures are described, and the calibration of the instruments is explained at some length. In the section dealing with optical pyrometers the author suggests that the electric lamp, if properly aged, will supplant the amyl-acetate flame as a standard of comparison. There is a distinct part of the book devoted to furnaces used in the calibration of high-temperature pyrometers.

BOOKS RECEIVED.

The Book of the Light Car. By E. T. Brown. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C. 2. Price 7s. 6d. net.

Industrial Furnaces. Volume II. By W. Trinks. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C. 2. Price 27s. 6d. net.

Reid's Handy Colliery Guide and Directory. Newcastle-upon-Tyne: Andrew Reid and Co., Ltd., Printing Court Buildings. Price 3s. 6d. net.

Combustion in Power Plant. Second edition. By T. A. Marsh. London: Constable and Co., Ltd., 10–12, Orange-street, W.C. 2. Price 12s. net.

The Secret of High Wages. By B. Austin and W. Francis Lloyd. London: T. Fisher Unwin, Ltd., 1, Adelphi-terrace, W.C. 2. Price 3s. 6d. net.

Proceedings of the American Society for Testing Materials. Vol. 25. Philadelphia: American Society for Testing Materials, 1315, Spruce street, Pa., U.S.A.

Das Deutsche Warenzeichenrecht. By Dr. W. Pinzger and Dr. F. Heinemann. Berlin: Otto Liebmann, Potsdamerstrasse, 96, W. 57. Price 18 marks.

Chemical Engineering and Chemical Catalogue. Second edition. Edited by D. M. Newitt. London: Leonard Hill, 113, Fleet-street, E.C. 4. Price 15s. net.

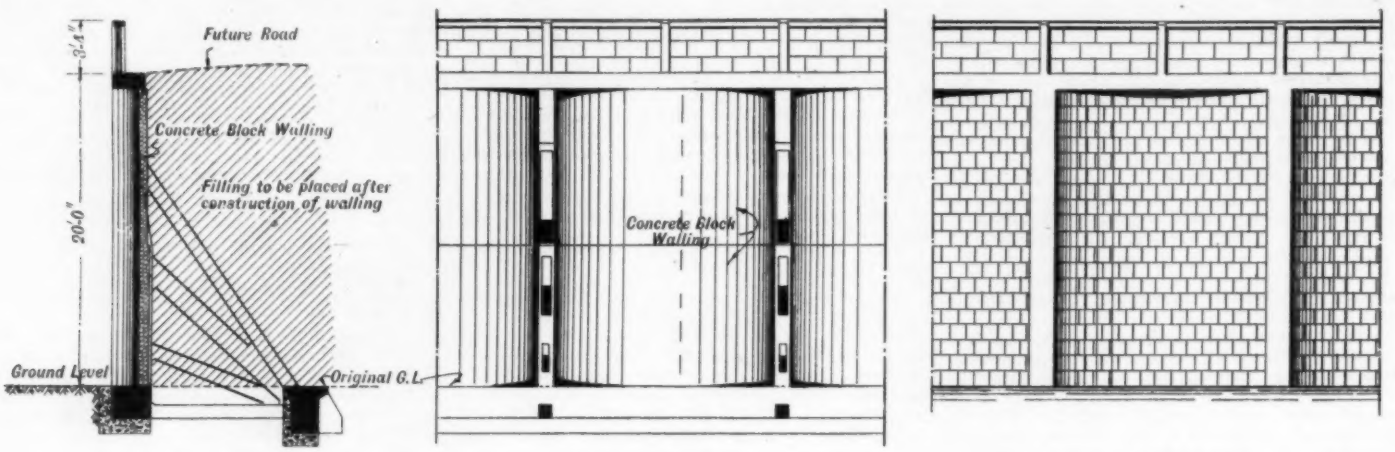
Year Book and Directory of the "South African Mining and Engineering Journal," 1926. Edited and compiled by S. R. Potter. Johannesburg: The South African Mining Journal Syndicate, Ltd., 176, Stock Exchange Buildings. Price 10s. 6d. net.

SIXTY YEARS AGO.

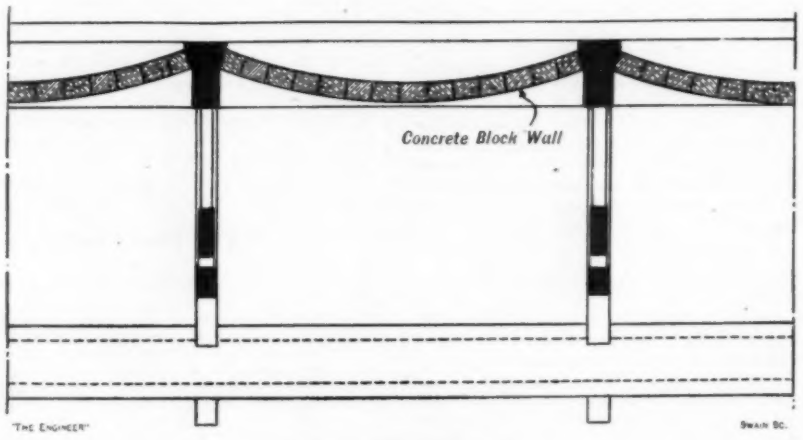
A process for the production of homogeneous steel castings free from cavities which, if it were ever tried, must have been an interesting one to watch—from a distance—was briefly described in our issue of March 30th, 1866. The inventor was M. Galy-Cazalat, and our account of his system was taken from a memoir which he had addressed to the Academy of Sciences. M. Galy-Cazalat, it seems, anticipated Bessemer's patent of 1856 in some respects. To produce steel from cast iron, he caused currents of superheated steam to pass through a bath of cast iron in fusion. In passing through the metal the steam was dissociated. Its oxygen burned the carbon, and incidentally oxidised some of the iron, while the free hydrogen combined with and removed the sulphur, phosphorus and other constituents which would render the steel brittle. The inventor experimented with this process in 1855. Like Bessemer, who a year later patented the use of compressed air in place of steam, M. Galy-Cazalat experienced trouble in determining at what point to stop the blow, and accordingly could not at first obtain a product of uniform quality. This difficulty was eventually overcome by a method involving the addition to the decarburated iron of 10 per cent. of spathic cast iron to restore the carbon required to convert the material into steel. The steel so produced was recast to give it homogeneity. In spite of the expense involved, the material, we read, had for three years been made on a large scale, and had been used for "railway bars"—presumably meaning rails. The inventor was not, however, content with the metal so produced. As cast in moulds, it was full of cavities, which weakened its tenacity. Ordinarily, the steel casting was improved by heating it and rolling or hammering it. Such rolling or hammering was supposed to cause the particles of metal to adhere closely, and to expel the air bubbles. It was a costly process and for some purposes an impracticable one, as, for instance, in the case of steel cannon with trunnions and handles. M. Galy-Cazalat therefore proposed to effect the elimination of the cavities by the application to the cannon or other casting of intense gaseous pressure, while the metal was still fluid. To this end, he sealed the mould with a cap carrying a tube and cock. When the cock was opened 10 grammes of powder—consisting of 80 parts of saltpetre and 20 parts of charcoal—dropped from the tube on to the liquid metal. Combustion ensued and produced 10 litres of gas per gramme of the powder. The imprisoned gas exerted a pressure on the surface of the metal, which was transmitted throughout the mass and eliminated the bubbles. There is no evidence in our report which can be held to imply that this process for the elimination of cavities in steel castings had ever actually been tried. The fluid compression of metals, as now carried out by means of hydraulic pressure, was placed on a practical basis by Whitworth in 1865, but others besides M. Galy-Cazalat had been engaged with the idea before his time. Bessemer himself patented in 1856 a process for the purpose, and like the French inventor tried to use gaseous pressure. Krupp experimented with liquefied carbon dioxide, Bonneville proposed to use gunpowder, and Jones, of Pittsburg, worked for some time with steam at anything from 80 lb. to 250 lb. pressure.

Reinforced Concrete Retaining Walls in India.

THE engravings given herewith and on page 386 and the accompanying drawings show the design and construction of a novel type of retaining wall that has lately been built at Ahmedabad in India in connection with the approach roads to a railway overbridge. The drawings show in section and elevation and in plan the type design adopted, which consists of a horizontally arched wall, constructed in concrete blocks on a foundation beam. These horizontal arches are built between skewbacks cast on a vertical counterfort, which is constrained at its base by the foundation beam and at the rear by diagonal ties securing it to the anchor beam behind. Road filling is subsequently filled up behind these walls bearing on the anchor beam, preventing overturning, while forward movement is prevented by both foundation and anchor beams being filled in solid against the earth on the side exposed to movement.



NEW TYPE OF REINFORCED CONCRETE RETAINING WALL



PLAN OF RETAINING WALL

PART OF EXTERNAL RETAINING WALL

This type of design has, it is claimed, been found to be very much cheaper than any of the standard text-book methods of retaining wall constructions, the bulk of the work consisting of block walling in a lean mix involving no *in situ* centreing or expensive reinforcement. In the reinforced concrete members the bulk of the construction occurs low down in the foundation and the anchor beams, which are readily filled from ground level without costly shuttering. The designers point out that it is only the diagonals and vertical members that require good casing, and that very little scaffolding is necessary. Furthermore, it is stated that this type of construction is very rapidly carried out, over a mile of walling of the design illustrated being carried out in a year.

In India the relative prices of brickwork and rubble masonry vary greatly in different localities, but generally the price works out at the low cost of 6d. to 9d. per cubic foot for a class of work sufficiently good for a gravity retaining wall. Consequently, with cement costing delivered about £4 to £5 per ton, and with imported steel at about 14s. per hundredweight delivered, it is difficult to design a concrete retaining wall to compete with local masonry or brickwork in lime mortar. Reinforced concrete, inclusive of centreing and all charges, would represent generally from 4s. to 5s. per cubic foot, a figure probably relatively very much higher than would obtain in England. Even under these adverse conditions this type of wall may, it is stated, be built in India for a clear 10 to 15 per cent. below the cost of a gravity wall in local materials and in half the time.

The work as shown in the illustrations was done by J. C. Gammon, Ltd., engineers and contractors, of Bombay, Singapore, &c., for whom Mr. R. P. Mears, Assoc. M. Inst. C.E., is chief engineer. An English patent has, we understand, been obtained for this type of retaining wall.

Industry and Trade.

THE Committee on Industry and Trade has just issued a volume entitled "Survey of Industrial Relations," the object of which is to give "authoritative information on the subject of the relations existing among those engaged in industry, in the hope that it will facilitate a better understanding of present-day industrial problems."

The first chapter gives an account of the growth of the population in the course of the last half century, and explains the changes which have taken place in its distribution by age, sex and occupation. The extent of emigration and the changes, past and prospective, in the size and composition of the employable population, are also described. The volume then deals with the question of wages in an exhaustive study made from official data of the changes in wage levels which have occurred since the years immediately preceding the war, and analyses the effect of these changes in relation to the contemporary change in the cost of living. Details of the prevailing systems of wage payment are given, and an attempt is made to compare prevailing wages in London and in the capitals of the more important industrial countries.

The Committee's calculations yield the conclusion that the prevailing rates of increase of weekly rates of money wages in the most exposed trades range from 45 to 75 per cent., with an average of about 60, while for the trades sometimes described as "sheltered," the increases range from 80 to 120 per cent., with an average of about 100. This discrepancy is not confined to percentage increases, but applies also to the actual level of rates of money wages. On the subject of the movement of wages in relation to the cost of production, the Committee estimates that if the existing conditions of effort, efficiency and other factors were equivalent to those prevailing pre-war—an assumption liable to be vitiated in individual industries—the figures indicate on the average a small increase in the wages element in the "real" cost of production—the rise being considerably above the average in the more sheltered trades—though in the case of some classes of skilled men in the exposed trades there has probably been a fall. It finds that, in industries in which time rates of wages prevail, skilled workers fully employed in industries directly exposed to foreign competition are, on the average, less well off than before the war, while, on the other hand, unskilled workers generally, and workers both skilled and unskilled in the so-called "sheltered" industries, have, generally speaking, if with some exceptions, improved their average position as regards purchasing power. As regards the effect of payment by results on these conclusions, the Committee points out that in any trades in which piecework has become materially more prevalent since 1914, the true average rise in weekly earnings will be somewhat greater than the recorded rise in time rates.

The Committee says that there are indications that payment by results has probably been gaining somewhat on payment by time, and describes certain special methods of industrial remuneration, such as profit-sharing and family allowances, in certain foreign countries.

In the third chapter, dealing with conditions of labour, an account is given of the reductions of hours which have taken place in this country since 1914, together with a description of the measures adopted in the industrially more important foreign countries to regulate hours of labour. The chapter also summarises what has been done in this country, both by statute and by voluntary action, to improve conditions of labour—including the Miners' Welfare Fund and the work of the Industrial Fatigue Research Board—and it gives some account of the voluntary welfare movement in other industrial countries.

Turning to the question of hours of labour, the Committee draws attention to the general decrease in hours which has taken place since 1914. It estimates that at that time the average weekly hours of industry were between 53 and 54, and that they have been reduced now to an average of about 48, or, roughly, an average decrease of 10 per cent. on the pre-war hours. It is remarked that the trade depression of 1921 and the following years, which resulted in a reduction of wages amounting to something like three-fifths of the increase between 1914 and 1920, had practically no influence on prevailing hours; and it is pointed out that, in pre-war years, while wage movements were subject to periodic fluctuations, there was a continuous tendency towards the shortening of the working day. Dealing with overtime, the Committee points out that there has been little general change since 1914 in the ratio between overtime and ordinary rates of pay, or in the overtime conditions generally prevailing. Proceeding to the question of hours of labour in other countries, it is explained that the movement towards reduced hours of labour in Great Britain is only part of a movement in the same direction throughout a great part of the world; and mention is made of the legislation enacted in a large number of countries for the establishment of maximum hours of labour, usually, in principle, eight a day, or 48 a week.

In a chapter dealing with unemployment, the course of unemployment since the year 1880 is traced, and a detailed account is given of the extent of unemployment, both nationally and in the various industries, during the last four years. Here, again, such material as is available in regard to unemployment in certain important foreign countries has been collected. A description is also given of an analysis of a sample of unemployed persons which was made by the Ministry of Labour, with a view to discovering the types of individual and the personal circumstances of those who have been unemployed during the industrial depression of the last few years.

Another chapter describes in detail the machinery for joint negotiation and for preventing or settling industrial disputes, and the arrangements adopted in a number of important industries, including Joint Industrial Councils

and Works Committees, are described. A summary is also given of the legislation for dealing with industrial disputes which has been enacted in foreign countries and in the British Dominions. In the same chapter an account is given of the industrial disputes involving stoppage of work during the last thirty years. The chapter also includes memoranda on Trade Boards and on Profit-sharing and Co-partnership. A number of interesting statistical tables bearing upon the descriptive material in the volume are appended.

The Committee has prefixed to the volume an introduction, in which it reviews the situation and points out some of the main considerations arising from the surveys.

The book, which runs to about 500 pages, including a comprehensive index, is published at the price of 5s. by H.M. Stationery Office.

Temperature Variation and Heat Stresses in Diesel Engines.*

By ROBERT SULZER.

In order that an internal-combustion engine may work reliably it is absolutely essential that adequate allowance be made by the designer for the stresses due to heat. This requires, in the first place, a knowledge of how the temperature varies in the cylinder walls, and it must also be possible to calculate the heat stresses from the given data of temperature distribution.

The distribution of temperature depends, above all, on the temperature of the gases, a factor which is itself not constant, but shows considerable periodic variation during the working cycle. The periodic variation of the gas temperature by more than 1000 deg. Cent. also causes a variable distribution of temperature in the cylinder walls, and to determine this a knowledge of the conditions of heat transmission on the gas and water sides of the walls is also required. These data can be obtained, at least to a first approximation, from indicator diagrams and measurements of the temperature, &c., of the cooling water. A coefficient of heat transmission varying within wide limits in the course of the working cycle has to be reckoned with from the very outset, especially in the case of the transmission of heat from the gas to the walls.

It is at once clear that it is especially the curve of temperature variation in the walls which will be affected by this great variation in heat transmission. But even for the constant mean temperature of the walls, it is also of great significance that the coefficient of heat transmission

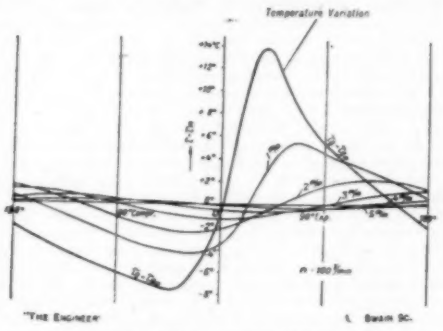


FIG. 1—CYLINDER WALL TEMPERATURE VARIATION

near the upper dead point, where the pressure is high, is many times greater than the mean coefficient of heat transmission, since it follows from this that an uncooled wall is heated not only to the mean value of the gas temperature, but can even be hotter—up to 200 deg. Cent.

Before describing the experimental work which has been carried out on this subject, we will first of all consider the circumstances with the help of some preliminary calculations which were made.

The general theory of the flow of heat in a body was developed a century ago by Fourier, starting with the consideration that the amount of heat entering each unit volume of the body in consequence of the differences in temperature causes a rise of temperature in this element corresponding to its specific heat.

The distribution of temperature in the cylinder walls can be resolved into a mean constant temperature, and periodic temperature variations superimposed on the constant temperature. The periodic variations force their way from the gas side into the interior of the wall; but, as will be shown, only a few millimetres below the surface of the metal, so that when discussing them the exact shape and dimensions of the walls may practically be neglected, whilst, for the constant part of the temperature, the shape given to the walls is of the utmost importance.

First of all, with regard to the periodic variation in the temperature, we find in the surface of the metal on the gas side a fluctuation of about the same character as the gas temperature curve, but varying only a few degrees up or down.

Thus we find, for a two-cycle engine running at full load at 100 revolutions per minute, the curve of surface temperature—shown in Fig. 1—which may be taken as characteristic of the walls of the combustion chamber.

In a surface in contact with the gases, the temperature varied periodically about a mean value, but only by about 14 deg. Cent. above and 8 deg. Cent. below, in spite of the huge variation in the temperature of the gases in the cylinder during each revolution of the engine. Inside the walls the variations in temperature die down rapidly, and the curves gradually change their character by flattening out, with a certain phase lag. Already at a depth of 5 mm. the variation in temperature still perceptible is less than ½ deg. Cent.

In Fig. 1 the temperature curves are given for layers at various depths from millimetre to millimetre, the temperature in the walls at the moment being given for each position of the crank. A few characteristic curves for the first 5 mm. depth of wall are given in Fig. 2. Although the gas temperature varies between wide limits, from scavenging air temperature to the highest temperature attained during combustion, the variations of temperature in the wall are so slight that they affect the constant temperature practically only to a depth of 5 mm. In spite of that, the amount of heat flowing into the walls shows considerable variations, although the variations in temperature are only slight; this can easily be understood

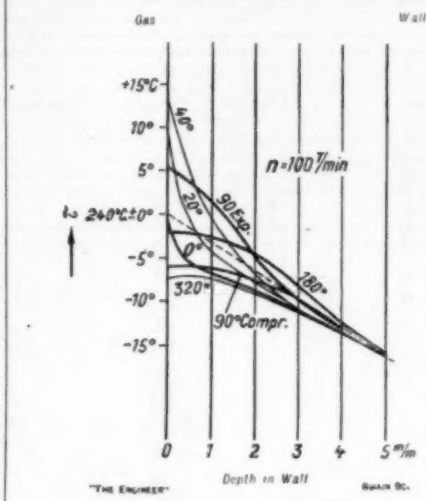


FIG. 2—TEMPERATURE IN INTERIOR OF WALL

when one considers that the heat flow depends, not on the temperature itself, but on the difference of temperature, i.e., on the slope of the temperature cueves at entry. According to Fig. 2 this slope may reach an amount many times as great as the permanent one, i.e., the amount of heat flowing in shows considerable variations up to several times the permanent amount—see Fig. 3. The heat flowing in is first stored in the layers near the surface and then, in the course of the working cycle, passes farther into the wall, or also—to a slighter degree—flows back to the gas.

The curves refer to an engine running at 100 revolutions

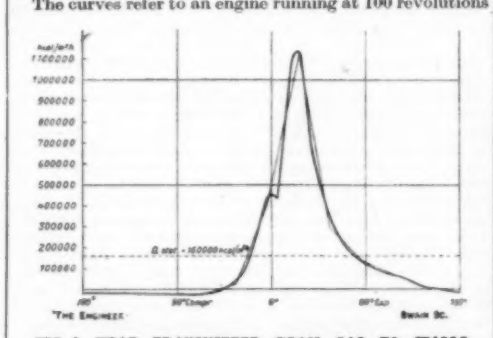


FIG. 3—HEAT TRANSMITTED FROM GAS TO WALLS

per minute—for other speeds the ordinates change inversely at the square root of the speed; the variations in temperature and the periodic heat stresses caused by them must, therefore, be specially considered in the case of slow-speed engines. In spite of the slight temperature variations by which they are caused, these stresses are considerable; for example, at full load and at 100 revolutions per minute they vary periodically between 120 kg./cm.²—1700 lb. per square inch—tension and 200 kg./cm.²—2800 lb. per square inch—compression. They come, therefore, into consideration, particularly as

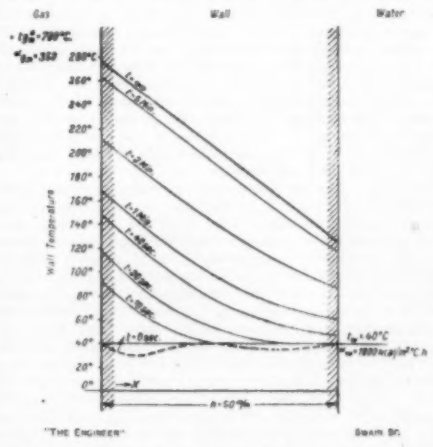


FIG. 4—WARMING UP TEMPERATURE CURVES

periodic additional stresses, superimposed on the mean stresses due to the constant heat flow.

Concerning the change in temperature with change of load—an important point with regard to the desirability of being able to start up a Diesel engine quickly—without any previous heating up, as in the case of a steam turbine—calculations for a flat cast iron wall 50 mm. thick give the curves shown in Fig. 4, when the engine is started quickly and put on full load at once. These curves show the change of temperature at various periods after starting up. The cylinder warms up at first by taking a considerable quantity of heat into the walls without at the same time giving up any to the cooling water. Accordingly the temperature at the surface in contact with the gas rises very rapidly in the first few seconds, and then more slowly until, theoretically after an infinite length of time, it attains a stable condition. After five minutes the difference is, however, already less than 15 deg. Cent. The sharp curvature of the temperature curves at the start is specially significant, as this, of course, implies additional heat stresses.

The effect of these additional heat stresses during changing load is shown in Fig. 5. The stress curves shown are at 10, 20, and 40 seconds after starting the engine. The material is assumed to be cast iron, and the curves hold for a flat plate perfectly free to expand and to bend. Compression stresses arise both on the gas side and on the water side, whilst the intermediate layers of the wall are in tension. It is a striking fact that the stresses on the gas side are particularly high after 10 seconds and quickly decrease, whilst at the same moment the stresses on the water side are still small and continue to increase further until 40 seconds. They then exceed the stresses on the gas side.

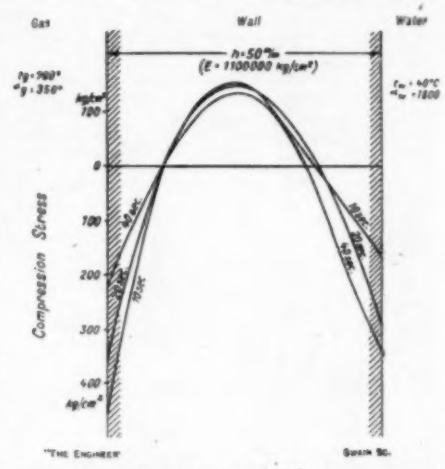


FIG. 5—STRESSES WHEN STARTING UP SUDDENLY

If the plate is held so that it cannot expand and bend freely, these stresses are superimposed on a linear distribution of stresses with compression on the gas side and tension on the water side.

The change in the stresses during the first minute after starting the engine can be seen particularly clearly from the curves in Fig. 6. The compression stresses on the gas side—curve *a*—rise sharply to their maximum in 10 seconds and then fall again quickly. The compression stresses on the water side—curve *b*—increase more slowly; after 25 seconds they are greater than those on the gas side, and also decrease after attaining a maximum at 40 seconds. Curve *c* shows the additional stresses in the cylinder wall when starting up quickly. When the walls are not too thick these varying stresses are harmless, even when a load is thrown on the engine suddenly, as the tensile stress in the present case—walls 50 mm. thick—does not exceed 160 kg./cm.²—2300 lb. per square inch. The compression stresses are about 450 kg./cm.²—6400 lb. per square inch—and will be about twice as much for cast steel.

Accurate calculation of the distribution of the permanent

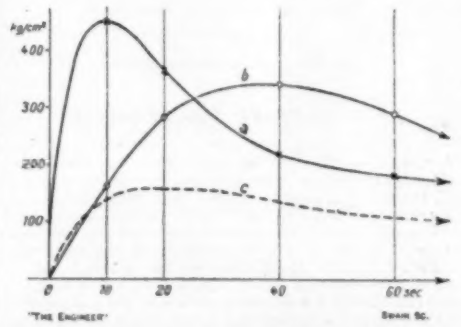


FIG. 6—STARTING UP STRESSES IN WALL 50 MM. THICK

temperatures in the cylinder walls is only possible for castings that are not too complicated.

Worked out for a water-cooled, cone-shaped cylinder cover with only one centrally arranged opening for the combined fuel and starting air valves, a system of isotherms was obtained—shown in Fig. 7—which satisfies the theoretical conditions of heat transmission. Here it was assumed that the gas temperature and the coefficient of conductivity were the same at all points in the combustion space.

The heat stresses corresponding to the distribution of constant temperature can in general only be submitted to a strict calculation when the axial symmetry of piston, cover, and liner is not too much broken by valves and ribs. We have then to deal with the problem of the stresses due to an axially symmetrical temperature distribution, the temperature in the direction of the meridian as well as in the direction of the thickness of the shell possibly varying symmetrically with the axis.

It is actually possible to determine the differential equations for the general case of axially symmetrical temperature distribution in hollow solids and to follow it up further for certain types of shells. These are shells with a constant radius of curvature along the meridian, *i.e.*, conical, spherical, and flat ring shells, including the two special cases of the cone, cylinder, and flat circular plate. These

* Paper read before the Institute of Naval Architects on Thursday, March 25th.

are the most important fundamental forms which come under consideration for cylinder walls. For the two-cycle cover shown in Fig. 7—a correct calculation of the stresses in the walls can also be worked out, as this design avoids any increase in stress which cannot be checked, such as cannot be avoided when the axial symmetry is disturbed either by valves or by ribs. The wall, water-cooled and exposed to the hot gases, is formed as a conical shell and is made as thin as possible in order to be capable of withstanding the heat stresses. In order that it may at the same time be capable of withstanding the gas pressure, it is supported centrally by the cylindrical tube—carrying the combined fuel and starting air valves—on a strong circular plate. An accurate calculation can be made with regard to the thickness of the shell and its proportion to the cylindrical parts and the circular plate.

Even in cases where the distribution of temperature is given only graphically, the problem can also be solved graphically. For example, in the case of a cylinder liner, the distribution of temperature being given by a system of lines—as shown in Fig. 8—and the thickness of the walls varying as indicated, the stresses and the amount of distortion can be calculated graphically; the results for a certain case are as plotted.

From these examples it is seen that, for the accurate determination of heat stresses, the purely symmetrical

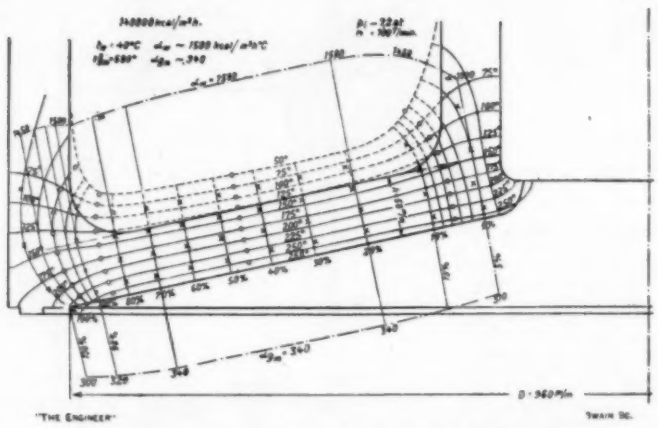


FIG. 7—TEMPERATURE DISTRIBUTION IN TWO-CYCLE COVER

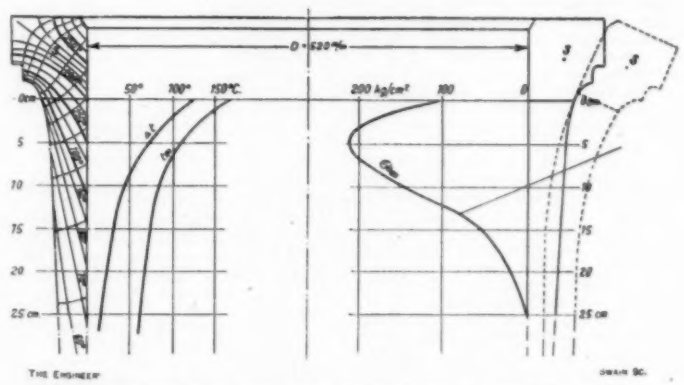


FIG. 8—DISTORTION AND HEAT STRESSES IN A CYLINDER LINER

shape of the cover, piston, and liner has a significance which cannot be overrated.

The reverse is shown in the four-cycle cover, the axial symmetry of which is broken up by valves, and which in the course of service is exposed to the danger of developing cracks, showing that "incalculability" is one of its essential features.

It might be mentioned here that we have experienced cases of cracked covers in four-cycle engines and two-cycle engines with valve scavenging in the cylinder heads, but never with the symmetrical two-cycle covers, except where the cooling system had not received proper attention.

The possibility of calculating the heat stresses is of the greatest importance to the designer of Diesel engines, particularly when dealing with large engines. Just because the most elementary difficulties, which at first hindered the development of the Diesel engine, have been overcome to-day, development can only be advanced by striving constantly to get a clearer conception of all phenomena and by finding means of controlling them.

(To be continued).

The Garratt Locomotive.

A PAPER on the Garratt locomotive by Mr. R. H. Whitelegg, managing director of Beyer, Peacock and Co., Ltd., Gorton, was read before the Manchester Association of Engineers on Friday, March 12th. Before dealing with the Garratt engine, the author described the principal features of earlier articulated locomotives, beginning with the Fairlie type in which there are two steam bogies or trucks placed under a double boiler, that is, one having a central fire-box and a barrel at each end, the trucks being attached by pivot centres to a girder frame on which the boiler is carried. The first engine of this type, the author said, was built in 1864 for the Neath and North Brecon Railway by Cross and Co., St. Helens. In spite of the trouble experienced with the steam pipes, this type of engine had a considerable vogue for work on sharp curves and steep gradients. It had another disadvantageous feature in the central fire-box which had to be fired from one side of the engine in a confined space. With a view to overcoming this feature, some Fairlie engines were built with two separate boilers, mounted on a girder frame, but, generally speaking, the author said, the Fairlie type of engine was now obsolete. The Pechot-Bourdon locomotive used by the French Army for military purposes was also, to all intents and purposes, a Fairlie.

The second engine to be built of the articulated class was the Meyer, which followed the Fairlie. The original design, which was never built, was exhibited at the London Exhibition in 1862, and was similar to the Fairlie in that two steam-driven bogies were used, but the boiler was of the normal locomotive type. The type in its original form did not develop into very big units, but the English variant of the type, known as the Kitson-Meyer engine, had developed very much from the original design, both in details and in size. By reason of the water and fuel tanks being carried on the boiler frame, the size of the boiler was naturally restricted. Consequently, when large quantities of water and coal were required, a separate tender had to be provided. The author then described the principal features of the "Mallet" type, the first of which was built in 1887. This locomotive consists of two engine units, the front being articulated and the hind unit being of the normal frame construction, on which the fire-box end of the boiler is carried. In the "Mallet" the front end is not pivoted centrally, but is hinged to the front portion of the hind unit, the boiler being carried at the front end by a sliding cradle resting on the articulated unit. The author's criticism of this type of articulation was that when the engine rounded a curve by reason of the boiler not following the bogie, the weight was transferred to one side or the other of the bogie according to the curve. He illustrated, as an example of "Mallet" construction comparable with British locomotives for overseas railways, an engine built for the North-Western Railway of India, which are 5ft. 6in. gauge, had a tractive power of 52,600 lb. at 85 per cent. boiler pressure, and weighs, with tender, 188 tons. Mr. Whitelegg said that none of the above-mentioned types was capable of being used for fast passenger work, as large coupled wheels could not be embodied, owing to the proximity of the boiler, nor were these engines good riding vehicles at high speeds.

Coming to the Garratt engine, he pointed out that the primary object was not the provision of an articulated engine as such, but the construction of a locomotive of high power, embodying a boiler having dimensions beyond anything possible in the normal rigid type of locomotive without exceeding the weight per axle allowed by the permanent way. Briefly, the Garratt locomotive consisted of three parts, *i.e.*, the boiler unit and the two steam driving bogies or units. The boiler unit, which consisted of long plates or girders extending beyond the length of the boiler at both ends, was carried at its extreme ends on the two steam engine units, the connection between the three being by cast steel pivot centre. The wheels were thus clear of the boiler which was left free, and the fuel and water tanks were mounted direct on to the engine units. The result of that arrangement of the units was that all the difficulties or disadvantages present in the other three types were eliminated, as the boiler was unrestricted by the proximity of the wheels and was of the utmost simplicity in design, avoiding undue length of tubes, expensive combustion chambers and difficult-shaped flanged plates which were required in other designs; in fact, it was composed of only nine plates, each of the plainest form possible, while the proportions of the fire-box, which was an essential part of the boiler, was such that its volume permits of practically perfect combustion in itself, resulting in low fuel consumption.

Again, owing to the fact that the boiler was clear of the wheels, it was possible to have them of large diameter, a feature which was quite impracticable with the other types, while the mounting of the fuel and water tanks direct on to the engine units took advantage of the inertia of those parts as a steadying factor when running. The desired distribution of weight on the various axles was obtained as a result of careful mathematical calculations locating the position of the pivot centre on each unit, that, of course, being the point of application of the weight of the boiler unit. The author said criticism had often been made of the Garratt locomotive as being a complicated machine; but, in fact, it was not so, as it was two ordinary engines with one boiler, the only additional parts being the articulated steam pipes. There, again, as a result of prolonged experiment, a simple type of ball joint had been evolved, which had proved absolutely reliable and free from any trouble whatsoever.

The location of the boiler on a girder frame quite clear from wheels rendered it exceedingly accessible for washing out purposes. Similarly, the ashpan under the fire-grate could be got at not only from the front, but also from the side for cleaning purposes, that being a distinct advantage in saving both labour and time. From the driver's point of view the control gears on the footplate were those of an ordinary engine, as he had no more levers, &c., to handle than was usually the case. Considered as a vehicle, the Garratt locomotive displayed many advantages not only over other articulated types, but also over ordinary engines.

The author added that in spite of the enormous power represented by the Garratt engines recently built and now under construction, it was already foreseen that the maximum would be reached as regarded designs for lines on which the permissible axle load was not great, and it had accordingly been found necessary to consider the possibilities of further increasing tractive power. With that end in view, a new type of articulated locomotive had been worked out by the licensees of the Garratt, which had also been patented. That design combined all the good features of the Garratt, plus the "Mallet" types. The articulation of the boiler unit and the inner end power units were similar to the Garratt, while the outer end units were articulated to the inner ones on the lines of the "Mallet" engine, that was to say, the outer units were hinged to the inner and not pivoted to the frame above. With that combination, practically unlimited power could be provided. As yet a further development of the articulated locomotive, the idea of the turbine condensing principle had been incorporated in the "Garratt" type, and patents had been taken out covering its application.

The paper was illustrated by a large number of lantern slides made from photographs of the engines referred to.

What is Sea Speed?*

By REGINALD J. EYRES.

THE suggestion of writing this paper presented itself to me as the result of a member of Council of the Institution asking the question at a Council meeting: "Is it possible to have a definition of sea speed?" Complete silence reigned till our President in his most persuasive manner appealed to members present for an expression of opinion. A few guarded remarks were made and I then expressed the opinion that at least three years are required before one can say what the sea speed of a vessel is and even then it would be a gamble whether the next voyage would be better or worse than her average performance. That this paper purports to answer the question is far from my mind, but if it results in some simple definition, acceptable to all concerned, being evolved then it will have served a useful purpose and prevent much disappointment in the future between shipowners and shipbuilders and incidentally between the shipowner and his consulting engineer.

An owner contracts for a steamer, and is told she will have a sea speed of 9 knots. On the trial trip she does 10 knots or more, but at the end of twelve months' trading her average speed works out at 8½ knots. Recrimination clouds the horizon and even litigation is threatened. This not infrequent and unfortunate state of affairs probably could be prevented if the conditions under which the builders expect the vessel to be running to give the sea speed that they anticipate she is capable of performing were made quite clear to the purchaser.

If there is this difficulty of ascertaining the sea speed of an individual boat, it is obvious that the difficulty of making comparisons between, say, two sister hulls with different types of engines is infinitely more so. The main points affecting the question forming the subject of the paper are as follows:—

Trial Trips.—Trial trips undoubtedly serve a useful purpose inasmuch as slight defects reveal themselves which might very materially affect the maiden voyage as a commercial enterprise if the ship had proceeded immediately on her projected voyage, but do not serve the least purpose in establishing a sea speed on which an owner can rely. Incidentally, over an experience of twenty-six years it has been quite the exception for anything to go wrong that could not be dealt with by the contractors' men and with very little loss of time, which speaks highly for the material and workmanship of our shipbuilders and engineers. Well authenticated cases are known where the economical running of a steamer under ordinary trading conditions has been ruined for the whole of her career in order to get a big horse-power with corresponding speed results on trial trip at a prohibitive consumption.

Wetted Surfaces.—The deterioration of under-water painted surfaces is of paramount importance and, generally speaking, does not receive the consideration that it calls for. Owners do not appreciate what it is costing them in coal by running their vessels too long without dry-docking and painting, or again not to have them chipped, particularly between wind and water, when they are four or five years old and have accumulated a quite appreciable scale offering a very rough surface.

Coal and Oil Fuel.—Now we are on very thin ice; but, fortunately, it is a recognised fact that the variation in quality of fuel, perhaps less so in oil fuel than bunker coal, is a serious difficulty to the shipowner. An owner knows perfectly well that quantities in foreign coal bunkering stations are subject to a certain percentage of shortage, and can make his calculations on this accepted shortage; but the quality he cannot foresee, and what the resultant consumption per day will be, and not infrequently an otherwise good voyage for comparative purposes loses its value by the vessel's having to bunker abroad. Steps, I believe, are being taken to arrive at an international standard or standards of oil fuel, and such standardisation does not seem to be out of the range of possibility; but, of course, such a happy state of affairs is out of the question with coal and it is no doubt a strong point for the internal combustion engine or oil fuel heating of boilers.

* From a paper read before the North-East Coast Institution of Engineers and Shipbuilders, March 12th, 1926.

It is obvious that the quantity of air required varies with the many different kinds of bunker coal; but it would be an impossible proposition for a ship to carry two or three different sets of fire-bars about to suit the varying nature of the bunkers it will perforce be obliged to use; yet in this regulation of air for variation in coal lies another important factor in good steaming and the vessel's performance on a long voyage.

The Human Element.—Under this head comes perhaps the most difficult of all our problems. Here you have the undoubted superiority of one captain over another as a navigator and in a comparatively short voyage such a difference is by no means a negligible quantity, particularly when you are trying to find an expected or promised 5 per cent. economy in fuel on a comparatively low consumption.

One chief engineer can get better results out of the same engine than another by constant attention to adjustment of valves, and nursing his engine to meet the prevailing weather and sea conditions.

Under the same conditions and with the same coal, one set of firemen will fail to keep a steady head of steam whilst another will be on the blowing-off point nearly all the watch, and it would be superfluous on my part to tell you what that means.

Percentage of ashes, if high, reflects itself in two ways: there is the time taken to get rid of them, and the steam used in the ash hoist. It may be thought that it is straining a point to mention such a trivial item as the steam used in the ash hoist; but take a thirty-day voyage, where the ash hoist is used six times a day, that is, 180 times. If it is used half-an-hour longer each watch due to inferior coal, you have ninety hours of what is often a very wasteful steam user. Another point to remember is that this engine is under the control of men whose one object is to get ashes dumped as quickly as possible and they do not spare the engine.

The galley. Have you ever thought about it? The galley fire is never out or rarely so. Ask the good lady at home how much coal she would need to cook for thirty-five or forty men, including bread-making, in a week and multiply that by, say, 6. Well it represents many tons in a six weeks' voyage, and although not inferring that it is never apportioned fairly, you have on the one side the captain anxious to keep the quantity down for the glory of his department, and on the other side a keen engineer trying to show 1·5 lb. per indicated horse-power. One hundredweight a day does not sound much, but if the engineer succeeds in debiting the galley with it for forty-two days, he is a little over 2 tons to the good, and where you are dealing with a low consumption of about 25 tons a day "many mickles make a muckle."

This human element section cannot be left without a passing remark on the constant, but every varying, recognised winds and currents because not a little depends on how an intelligent navigator can utilise or avoid them as the circumstance arises.

It will be readily seen that if a vessel is fortunate enough to have a favourable trade wind or monsoon, as well as a favourable current, her performance will soar above her normal best work, and that under adverse conditions, if by careful navigation these currents and winds can be partially avoided, a very bad day's run can be avoided or at least mitigated.

Propellers.—Is it a constructional possibility to make two propellers alike? I am advised that it is, but quite frankly I am doubtful if, in fact, such conditions are obtainable in practice, and when it comes to making comparisons this uncertainty needs to be eliminated.

When crossing the Atlantic recently in one of the big liners there was just perceptible a peculiar and unusual jerking movement from port to starboard. The chief engineer was of the opinion that a new starboard propeller recently fitted was not the same as the port propeller, and said that he hardly ever got exactly the same results from two propellers supposed to be identical.

Again, it is quite common knowledge that a bronze propeller will alter its shape as the result of a succession of bad weather voyages. However, we know that propellers are receiving a great deal of attention and much useful research work is going on, which will materially help to arrive at a higher efficiency.

Weather Reports.—If we consider the Beaufort scale, with its delicate graduation, does it not occur to you at once that it offers some difficulty in differentiating as between any two consecutive conditions?

Do you not think that much might depend on the chief officer's state of health as to whether he writes up his log "moderate sea" or "rough sea"? I have known the time when I should have entered up a rough sea as a hurricane, and stronger than that if such a term existed. It may be taken that, generally speaking, the average officer rather underestimates if anything the state of the weather, unless a bad passage has to be accounted for to a very exacting owner.

There is more behind these facetious remarks than perhaps you expect, and if you had twenty or thirty log extracts before you and were endeavouring to arrive at a comparison, I venture to think you might find yourselves in something of a dilemma, and, of course, it is of the greatest importance.

One cannot pass over the nature and stowage of the cargo as of no consequence. Very often it is out of the control of the captain to arrange his parcels to suit the best steaming conditions of his ship owing to the various destinations of the cargo, and it not infrequently happens that he may be slightly down by the head, and his cargo so placed as to set up a strong rolling period; either or both of these conditions will materially affect the performance of that voyage.

I have had in mind throughout this paper vessels under loaded conditions, but unfortunately most tramp steamers to-day are steaming almost as many days under ballast conditions as when loaded. The same difficulties present themselves in either condition when endeavouring to ascertain the sea speed; if anything it is more difficult in the case of in ballast, because the human element enters so largely into it. A good understanding between captain and engineer, careful nursing of ship and engines to suit the ever varying conditions, such as alteration of trim by adding or pumping out ballast, may make a very considerable difference in the performance of a thirty to fifty-day voyage.

The Internal Combustion and other Types of Engines.—An endeavour has been made in this paper to show the importance to an owner of knowing the sea speed of his vessel, but of still greater importance is the cost of this sea speed; it is, in fact, the most important, and we cannot in this paper disassociate one from the other. In Mr. A. J. Campbell's article, "The Position of British Marine Engineering," in The Engineer, October 9th, 1925, amongst many intriguing remarks, he said: "The economic side of the Diesel oil engine has never been clearly stated." It is unfortunately too true, and if such gentlemen as Mr. Campbell cannot get this information, how are we consulting engineers to get it? The same can be said of any departure from the ordinary steam reciprocating engine. As, however, we have not by a long way seen the last of still greater efficiency in the steam engine, and are watching Sir Charles Parsons' experiment with great interest, there is no need to labour this point further.

Comparative Performances of Ships.

ss.	Days under steam.	Weather. Good.	Mod.	Bad.	Worst day's run.	Best day's run.	Average I.H.P.	Average coal.	Average speed.	Average % ash.	Average % slip.	Average vac.	Average steam.	Average revs.
"A" ..	196	41·5	35·6	22·9	2·3	10·2	1465	25·8	8·61	15·5	12·0	23·7	168	61·4
"B" ..	154	39·6	39·2	21·2	5·4	10·6	1522	26·2	8·76	13·2	11·5	24·2	169	62·2
"C" ..	138	61·5	24·1	14·4	6·1	10·8	1420	26·9	9·09	14·3	9·64	24·0	169	62·7
"D" ..	40	54·2	25·8	20·0	7·4	10·5	1553	26·1	9·23	15·4	8·08	24·8	170	63·5
"E" ..	14	45·0	10·0	45·0	6·5	10·3	1380	23·6	8·9	13·8	10·7	24·0	169	62·4

Performance of Five Sister Ships.—By permission of one of my clients, I am able to show you in the above Table, the performances, up to date, of five sister ships, with one or two variations which will be pointed out. This table of comparative performances is due to the short period under observation, of very little value, and is not intended to show the merit of one ship over another; but it very usefully serves my purpose of demonstrating the difficulties and variations that can and do pertain to statistical work of this nature.

Steamer "D" is in every way the same as her sister ships, except that she is built on the Monitor system. The particulars given are taken from the extracts of the official log books, and I should like to add that all the information given by the respective log books has been carefully scrutinised by both the owners and ourselves, and we have no reason to believe that they are not correct.

Steamer "E" has had superheat from the inception of her career. Before looking at the figures presented in the table a few remarks are necessary.

Deadweight must nearly always be a variable quantity, particularly with coal and grain cargoes, which after all are probably the cargoes most often carried. In the five ships concerned practically nothing else but coal or grain has been carried. Further, there is a variable quantity of fresh water carried above the deadweight given, but it is never in such a quantity as to affect materially the results.

Steaming Days represent midday to midday irrespective of whether bound east or west. It would have been more correct to calculate each passage twelve hours after leaving port, thus first eliminating the question of poor steam due to lying under banked fires for sometimes several hours before getting under way, and secondly, when leaving a home port, allowing time for the firemen to recover from "the night before."

Weather Conditions have already been referred to.

Best and Worst Day's Run.—The figures given are the best and worst day's run for each vessel.

Average Indicated Horse-power leaves much to be desired, inasmuch as cards are not taken at frequent intervals during the voyage. As you will appreciate, to obtain absolutely ideal data all engines should be read at the same time, and no one indicator should be used on the same engine for two consecutive readings The indicator itself is a sensitive instrument and liable to fluctuate.

Average Consumption represents all qualities taken, but, generally speaking, good qualities of both North Country and Welsh coal.

Average Speed is taken just as it appears in the log book, and after all, when taken over a period of two to three years, is probably nearly correct.

Conclusion.—Although all possible difficulties of arriving at sea speed may not have been explored, perhaps enough has been said to evoke some suggestion of a suitable clause regarding sea speed for inclusion in all contracts. Speaking as one who has many new steamers passing through his hands, the author very sincerely hopes that some such clause may be evolved. Research work on colliers and tramp steamers may not be as spectacular as on large passenger boats and vessels of the Royal Navy, but to us on the North-East Coast it is of supreme importance if we are to uphold our reputation of producing and maintaining vessels of this class.

THE ROYAL INSTITUTION OF GREAT BRITAIN.

The following arrangements have been made for the after Easter Session of the Royal Institution:—

The Friday evening discourses will be continued on April 16th, when Dr. Arthur W. Hill, F.R.S., Director of the Royal Botanic Gardens, Kew, will discuss "The Quest for Economic Plants." On April 23rd Dr Richard Whiddington, Cavendish Professor of Physics, University of Leeds, will give a discourse on "The Luminous Discharge Through Rare Gases." On April 30th, Dr. W. H. Eccles, F.R.S., will deal with "Wireless in the Empire." On May 7th, Sir Frederic G. Kenyon, Director and Principal Librarian, British Museum, will treat of "English Illuminated Manuscripts," while on May 14th the subject will be "The Golden Eagle and its Neighbours," and it will be in the hands of Mr. Seton Gordon, F.Z.S. The title of the discourse for May 21st will be announced later. On May 28th, Sir Almroth Wright, F.R.S., will discuss the "Aims and Methods of Therapeutic Research." On June 4th, Dr. John Garstang, John Rankin Professor of Archæology, University of Liverpool, will tell of "Researches in Palestine," and on June 11th, Dr. J. C. M'Lennan, F.R.S., Professor of Physics and Director of the Physical Laboratory, University of Toronto, will lecture on "The Spectrum of the Aurora."

The discourses are delivered at 9 p.m.

The following is the programme of the general courses of Lectures for the after Easter Session:—Tuesdays, April 13th, 20th, 27th and May 4th, "Organs of Multiple Function—(1) The Salivary Glands; (2) the Spleen; (3) Feathers; (4) Lungs," by Mr. Joseph Barcroft, F.R.S., Fellow of King's College, Cambridge, and Fullerian Professor of Physiology. Tuesdays, May 11th, 18th, 25th, "The Acoustics of Public Buildings," by Dr. G. W. C. Kaye, Superintendent of the Physics Department, the National Physical Laboratory (the Tyndall Lectures). Tuesdays, June 1st, 8th, (1) "Shah Abbas of Persia, the Contemporary of Queen Elizabeth"; (2) "Chinese Turkestan and the Pamirs," by Brigadier-General Sir Percy Sykes. Thursdays, April 15th, 22nd, (1) "French Rhythm and English Poets in Norman and Modern Times"; (2) "Anglo-Norman Literature: an Introduction," by Mr. Oliver H. P. Prior, Fellow of St. John's College, Cambridge, Drapers Professor of French, University of Cambridge. Thursdays, April 29th, May 6th, 13th, "The Imperfect Crystallisation of Common Things," by Sir William Bragg, F.R.S., Fullerian Professor of Chemistry. Thursdays, May 20th, 27th, "Corrosion, Tarnishing and Tinting of Metals," by Mr. Ulick R. Evans; Thursdays, June 3rd, 10th, (1) "Iron in Antiquity"; (2) "Science in Antiquity," by Dr. J. Newton Friend, Municipal Technical School, Birmingham. Saturdays, April 17th, 24th, "The Shipworm," by Dr. William T. Calman, F.R.S., Deputy Keeper of Zoology, British Museum. Saturdays, May 1st, 8th, "The Song Form in England as Represented by (1) Stanford; (2) Parry," by Dr. Percy C. Buck, Director of Music in Harrow School (with musical illustrations). Saturdays, May 15th, 22nd, "Atmospheric Electricity," by Dr. George C. Simpson, F.R.S., Director of the Meterological Office. Saturday, May 29th, "Une Révolution Sociale en Egypte Vers 2000 Av. J-C," by Alexandre Moret, Professeur au Collège de France, Paris. The subjects for Saturdays, June 5th, 12th, will be announced later. On Tuesdays and Thursdays the lectures begin at 5.15 p.m. and on Saturdays at 3 p.m.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

Michell Bearings, Ltd., of South Benwell, Newcastle-on-Tyne, asks us to state that Mr. Hubert B. Scott has been appointed local director of the company.

Mr. John C. Hafner, A.M.I. Mech. E., asks us to announce that he has resigned his position as works manager of the Skefko Ball Bearing Company, Ltd., and is shortly taking up a similar appointment with Electrolux, Ltd., of Luton.

Lindley Duffield and Co., Ltd., the head office of whom is at Brassington, Wirksworth, Derbyshire, ask us to announce that they have changed their London office from 199, Piccadilly, W. 1, to 11, Aldwych, W.C. 2. Their new telephone number is Gerrard 6753.

William Firth, Ltd., of Leeds, inform us that it has removed its offices from Greek Street Chambers, Leeds, to larger premises with stores and yard attached, known as Cavendish Road Works. No change will be made in its telegraphic address or telephone numbers, which will remain "Rails, Leeds," and No. 20638 respectively.

Ed. Bennis and Co., Ltd., announce that Mr. J. G. McLean is no longer in their service, and has therefore ceased to represent them on the North-East Coast and Sheffield and district areas. The name of his successor will be announced in due course, but in the meantime it is requested that communications should be addressed to the head office, Little Hulton, Bolton.

The Institution of Civil Engineers: London Students' Dinner.—The forty-fifth annual dinner of the Association of London Students of the Institution of Civil Engineers was held on Friday last, March 26th, in the Victoria Hall of the Criterion Restaurant. It was a most happy evening and a record dinner from the point of numbers. Mr. J. Kennard, Chairman of the Committee, presided, and the guest of the evening was Mr. Frederick Palmer, vice-president and president-elect of the Institution. The toast of "The Institution of Civil Engineers" was proposed by Mr. J. E. W. Monkhouse, honorary secretary of the Students' Committee. Mr. Monkhouse referred to the unavoidable absence of the president, Sir William Ellis, who had been suddenly called abroad. He also regretted the absence through illness of Dr. H. H. Jeffcott, the secretary of the Institution. Mr. Monkhouse was able to give a good account of the growth of the London Students' Section and remarked upon the increase in attendance at meetings and visits which had taken place during the year. He announced that the Institution had extended the privileges already enjoyed by the students by electing the chairman of the Students' Section in office as a member of the Institution's Informal Meetings Committee. In responding to this toast, Mr. Frederick Palmer referred to the honour attached to corporate membership of the Institution and the high professional status it implied. He assured the students present that the Council had their welfare at heart, and was pleased to note the growth of the number of students both in London and the provinces. Mr. Palmer strongly advised students to seek Indian or Dominion experience. The toast "Students of the Institution" was proposed by Sir Cyril R. S. Kirkpatrick, who emphasised the importance of modern language in the training of a civil engineer. Sir Brodie Henderson, Dr. Oscar Faber, and Mr. H. W. Cadman replied. The last speaker, on behalf of the Graduates' Section of the Institution of Mechanical Engineers, suggested that greater co-operation should take place between the students of the great engineering institutions. Mr. J. R. B. Griggs proposed the toast of "The Chairman," who had presided so ably and added to the success of the evening.

The High Efficiency Oil Engine.*

By ALAN E. I. CHORLTON C.B.E., Member of Council.

(*Concluded from page* 366).

IN proceeding with the consideration of the higher-speed engine we are at once faced with what has been more or less an unknown problem; that is, the burning of the oil fuel when injected, in a sufficiently rapid manner to give complete combustion, and to be, furthermore, within such high mechanical efficiency indicated, such types could not be considered. Furthermore, their cost of construction tends to be high.

A line of combustion development for intermediate higher speeds, so to speak, which has made considerable progress on the Continent and in America, though comparatively little in this country, has been evolved from the original design of Brons, in which a small cup or ante-chamber to the combustion space proper first received the fuel and evaporated a portion of it, which then being exploded, impelled the rest of the fuel through the fine

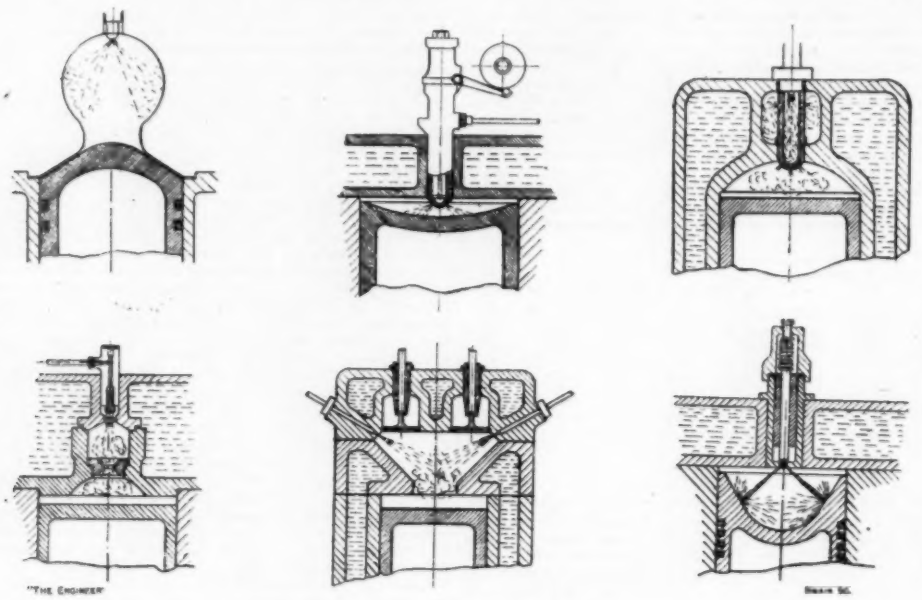


FIG. 6—TYPES OF COMBUSTION CHAMBERS

control as to allow of the heat being added as is most suitable, that is, at constant volume and/or constant pressure.

An additional difficulty from the design point of view is the very limited combustion space of the small cylinder.

The design of such an engine should, to be an advance, include weight reduction, for merely to built to permit the higher pressure would mean greater weight and cost. This, in effect also, indicates higher speeds of rotation as the remedy.

The complete combustion of heavy residual oils in quick-running engines having cylinders of comparatively small dimensions has engaged a good deal of attention latterly, and it has been many times stated that the difficulty of burning oil at rapid rates when sprayed into the cylinders was so great and had such little hope of practical success as to discourage development work.

Some small Diesel engines have been constructed with the typical air blast injection of fuel, and it is understood have run successfully, though it is suggested, to reach the orifices of the cup into the cylinder proper. This method, at one time, seemed to offer advantages for quick-running work and quite a lot of attention was concentrated on it, to which considerable public reference has been made.

As previously stated, steady progress has also been made in this country with the engine utilising plain fluid pressure injection of the fuel alone through an atomiser without any other complication, and the author's considerable experience in this line led him naturally, when carrying on experimental work with high speeds, to continue with the method.

The problem in its other aspect can hardly be brought to quite simple terms, for there are many variations in the way in which it may be attacked. Thus, the form of combustion chamber is important, and there are several different types of such chambers in use, Fig. 6.

The globular is the form that has sprung out of the Lincolnshire type of engine, and the flat type is, and always has been, the Diesel type proper.

In the consideration of the comparative merits of these, the question of turbulence plays an important part. In the globular type the connection to the cylinder proper has nearly always been through a conduit of reduced area, and by this means any degree of turbulence can be created. Turbulence goes to improve the degree and speed of burning, and in this wise assists in completing atomisation.

The disadvantage is that the flow through the narrow orifices causes loss of heat during the expansion stroke at a rate above normal. Mechanical strains are sometimes induced in this part for this reason.

In actual practice there is considerable difference in results between the two forms, but if a sufficient degree of turbulence can be obtained with the flat and simple form, together with good atomisation when higher speeds are used, then it would be better to adhere to this type.

There is another consideration that has to be borne in mind, and that is for small engines the flat form would appear to present the only way of getting a sufficiently high compression pressure and temperature. In mechanical

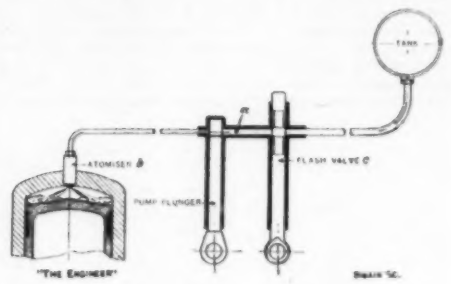


FIG. 7—FUEL PUMP SYSTEM

atomisation a rapid acting atomiser or injection valve is essential. In some systems this, as with the original Diesels, is operated mechanically, but the greater number at the present time employ an automatic valve whose action depends upon the variations in the pressure supply set up from the fuel pump proper.

Furthermore, the measuring of the discharge must be accurate and maintained, which for high speeds is still more difficult. The fuel pump has therefore a dual duty: firstly, to measure out accurately and consistently the requisite amount of fuel, and secondly, to inject or supply it to the cylinder under a high pressure with a rapid start and finish to its flow. Until these two conditions are fulfilled it will not be possible to obtain good combustion.

Atomisation has the following as fundamentals:—

(1) Definite injection period in continuous service.
(2) Precise measurement of fuel over long periods.
(3) Instantaneous cut-off action.
(4) Fine division to give sufficiently good rapid combustion.
(5) Discharge into all the air possible with avoidance of wall contact.

The fuel pump must be relied upon to give continuous accurate measured quantities of fuel and periods of injection. The length and capacity of the fuel pipe also affects the action of the whole. In a multi-cylinder engine running at a speed of 1000 revolutions, with cylinders of 8in. diameter, the fuel pump has to measure precisely a small quantity of oil for each cylinder and maintain its exactitude as well as to project the fuel into the combustion chamber in such a way as to secure complete combustion in a rapid manner.

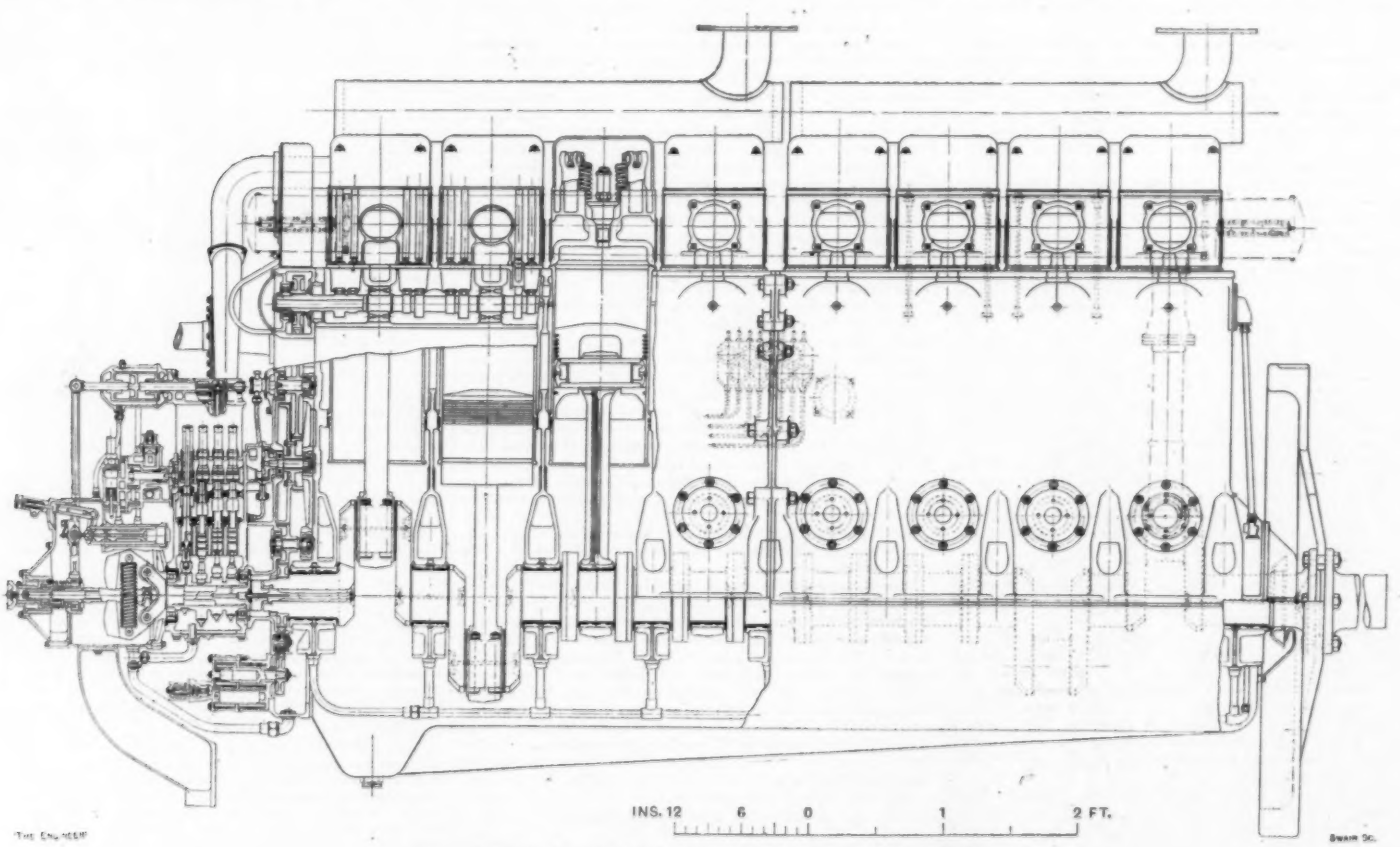


FIG. 8—BEARDMORE 400 B.H.P. HIGH SPEED HEAVY OIL ENGINE

* The Institution of Mechanical Engineers.

The principle of the type that the author has devised and used is shown in Fig. 7.

The main feature of this pump is that normally the plunger actuated by an excentric reciprocates the oil fuel backwards and forwards through the passage *a*. At precisely the right point this passage is interrupted momentarily by a valve travelling at high speed marked *c*, the effect of which is to send a vibration through the column of oil lying between this valve and the atomiser itself, marked *b*, with a reflex action, when the valve *c* reopens the passage *a*. With this vibration the atomiser valve is lifted off its seat and a small amount of oil forced past it at high pressure; it is then drawn on to its seat again by the reflex action, giving a sharp and effective cut-off.

Though the mechanical system of injecting fuel has made great progress, it is still, purely from the combustion point of view, not as effective as the air blast, with its excellent turbulence effect. This can be seen by a comparison of consumptions per indicated horse-power of the two types. Its great simplicity is the reason for the marked preference that is now shown for it.

On the other hand, the progress made indicates that before long it will equal the air blast on the indicated power, with the consequent increase in lead on that of the brake.

The author concludes with a short description of a quick-running engine manufactured by William Beardmore and Co., which, though not normally in service running at higher pressures, has by reason of its special construction in the use of a material like steel throughout the frame, its higher speeds of revolution, forced lubrication, &c.,

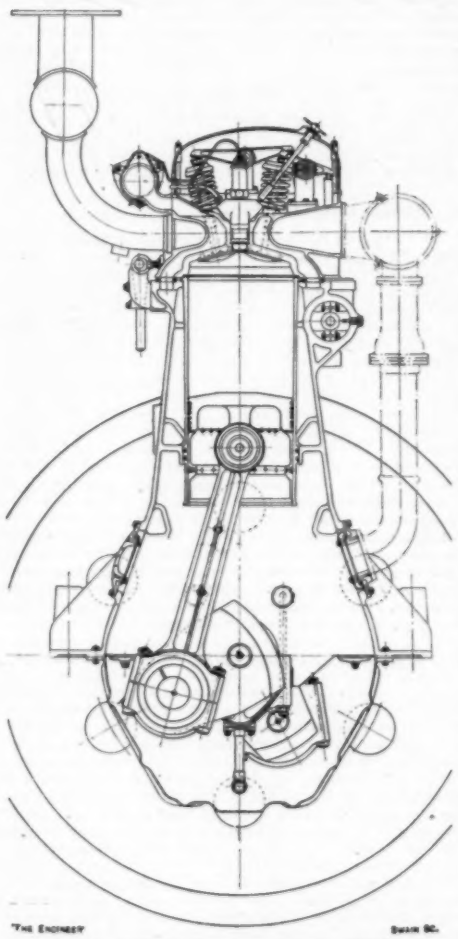


FIG. 9—SECTION OF BEARDMORE ENGINE

allowed of tests being made at such higher pressures. Unfortunately, these tests have not yet been completed, so the attainment of the highest results sought for has not been so far reached.

The results of three series of tests are given in Table VII. Series A was carried out on a standard engine with normal maximum pressure by Professor Mellanby. Series B was made on a similar engine with improved mechanical efficiency, the engine also having a much longer running life. In Series C a high maximum pressure was used,

TABLE VII.

Test series.	Duration of Test hours.	Speeds r.p.m.	B.H.P.	Fuel, lb. per B.H.P. per hr.	Cooling water temperatures. Inlet. deg. F.	Outlet. deg. F.	Fuel.
A	4¼	689·3	160·26	0·418	121·5	127·4	Sh'll-M'x Diesel
B	3	700·0	172·0	0·385	120·0	128·0	Sh'll-M'x Diesel
C	3	1007·0	424·0	0·365	140·0	150·0	Sh'll-M'x Diesel

It must be borne in mind when reviewing the results of the last series that the cylinders were of small diameter with a very high piston speed.

Figs. 8 and 9 are sections through an eight-cylinder engine with cylinders 8¼in. bore by 12in. stroke, running at 750 revolutions per minute and clearly reveal the design.

The whole frame is of special cast steel of cellular form, a square cell to each cylinder, the walls continuing to the crank shaft bearings, and carrying directly the stress due to combustion pressure. The liners are thin steel tubes, the pistons and the cylinder covers are of aluminium alloy. This engine is normally rated at 400 brake horse-power and weighs 2¼ tons.

In practice these engines have been applied to railway service with remarkable results, the economy achieved being considerable, giving a cost much below that of steam power. The engine, by a special relay governor, runs between 250 and 750 revolutions per minute according to the speed of train required. There is no engine attendant carried. The fuel oil used is standard Diesel; so far tests with speeds of revolution up to 1400 revolutions per minute have been successfully carried out.[11]

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Trade Situation.

BUSINESS in iron and steel on the Midland market this week has been extremely slender. Consumers will in many cases have extended holidays, and they have sufficient material in hand with which to resume operations after Easter. The general situation has been relieved by the avoidance of an engineers' lock-out, and the general impression is that the interview of the Premier with the coal parties has improved the prospect of a peaceful settlement in that field of unrest. There is still a disposition, however, to maintain a cautious attitude, and orders are placed merely to cover requirements until the end of April. Indications are that the first quarter of the year will not show any noticeable change from last year, which was a remarkably bad period.

Steel Prices.

The establishment of controlled prices for certain classes of steel after a year of free trading has virtually put an end to the keen price-cutting which has been a feature of the steel department for many months past. Particularly in the structural department has this competition been in evidence, and many producers consider that the new price level of £7 15s. per ton for ship, bridge and tank plates is lower than it should have been, but they are generally agreed as to the £7 figure for angles and joists. Neither price, however, permits of a large margin of profit with present production costs and limited output. More firms are now members of the Steelmakers' Association than formerly, and it is believed that the present effort to keep the price at a profitable level will be more successful than in the past. Steel works are moderately active, on constructional steel. So many large business houses are being reconstructed that a fairly substantial aggregate of steel is required. The railways also are good buyers, with substantial further business in prospect. For the time being, big contracts of a municipal character, as well as for foreign enterprises, are being withheld mainly on account of labour uncertainties, with their possibilities of price increases or restriction of fuel supplies. The rolling stock works are taking considerable quantities of iron and steel from Staffordshire mills. The supply of foreign steel is more limited than it was, many French works being filled with orders, and practically off the British market. A few German offers have been received at somewhat attractive prices, but except for certain descriptions of cold rolled steel and strip, Germany is not now a strong competitor. There are few German billets on offer, and the quoted figure of £5 7s. 6d. for Belgian material is not attractive, against the English price of £6. A few sales of continental "semis" have been effected notwithstanding.

Raw Iron.

The easier price tendency in the pig iron department continues. Pressure for lower prices is less capable of being withstood as existing contracts near completion, and furnacemen see little definite business to replace them. Nominally, recent rates are maintained; but it is reported that there has been a certain amount of shading in relation to No. 3 foundry grades. Derbyshire has been sold this week at £3 6s. at furnaces, 6d. per ton cheaper than a week ago. This week there have been tentative inquiries as to forward deliveries of pig iron. They do not appear to have led to much, however, the rates which consumers and merchants are prepared to pay for more than small scale lots being such as would show furnacemen very little profit in the most favourable circumstances, and might involve them in considerable loss. The position in the coal trade makes future production costs very uncertain, even assuming that the crisis is tided over without active conflict. Blast-furnace coke is in fairly plentiful supply at slightly easier prices, although there is an impression that this condition is temporary.

Manufactured Iron.

A fair amount of trade is passing in Staffordshire. Finished iron and marked bar prices remain at £14. With regard to Crown iron and nut and bolt grades demand is very irregular. The former is quoted at £11 5s., and the latter at £10 5s. Odd instances are reported in which £11 2s. 6d. has been accepted for unmarked Crown iron. For export Lancashire houses quote £11, and sellers report that lately there have been some good shipments to South Africa. The Black Country tube trades continue busy, and are taking good quantities of gas strip at £12 10s., occasionally absorbing the larger proportion of the output of individual works. There will be little activity next week, many of the mills taking an extended holiday. Manufacturers hope that a few orders may accumulate in the interim.

Sheet Values.

Makers of 24 gauge galvanised corrugated sheets are still booking good orders at £16, but many mills are prepared to make a concession of half a crown for desirable orders.

Steel Scrap.

Steel scrap is selling somewhat more freely, South Wales taking larger quantities, but buyers are in many instances declining to pay more than £3 7s. 6d., although merchants invariably quote higher prices, and occasionally get from 1s. to 1s. 6d. above this figure.

Half a Million Electricity Scheme.

The Coventry Corporation proposes to spend over half a million pounds on electricity extensions, and on Tuesday it decided to make application to the Electricity Commissioners for consent to proceed with the first complete section of the new generating station at Longford, at an estimated cost of £558,495. An increase in the supply of energy is required in view of the present and prospective demands on the undertaking. The capacity of the present generating station, which is situated in a thickly populated district and cannot be extended, is 31,200 kilowatts. The city's maximum load recorded to date is 26,700 kilowatts, and it is therefore deemed advisable, in order to cope with increasing demands, that an additional generating station should be erected. The site for the new station, comprising an area of 53 acres, was acquired in 1918, and the work would have been commenced at a much earlier date had it not been held up at the request of the Electricity Commissioners. It is estimated that the new station can be in commercial operation by October 1st, 1927.

Birmingham and the Electricity Proposals.

That further protective clauses are necessary in the Government's Electricity Bill for the safeguarding of authorities which have invested large sums of public money in up-to-date electricity schemes, such as that in operation in the West Midlands, is the opinion of the Birmingham Electricity Supply Committee. At a recent meeting of this body the Government's proposals were considered, and it is understood that in conjunction with other large supply authorities steps will be taken to secure adequate protection, having due regard at the same time to consumers' interests.

Iron and Steel Wages Board.

At the fiftieth annual general meeting of the Midland Iron and Steel Wages Board, held at Birmingham on Tuesday, the report and statement of accounts showed the Board to be in a satisfactory condition, though the receipts, both from employers and operatives, were less than in the previous year and insufficient to meet the year's expenditure. The receipts from employers amounted to £2449 18s. 1d., as against £2667 0s. 10d. last year, a decrease of £217 2s. 9d. The receipts from operatives amounted to £2463 12s. 7d., as against £2667 1s. last year, a decrease of £203 8s. 5d., making a total decrease of income compared with last year of £420 11s. 2d. The total receipts for the year were £4927 12s. 2d. and the expenditure £5028 4s. 2d. The Board, however, has a credit balance of £1206 18s. 6d.

Shipbuilding Recovery.

Birmingham and Black Country industrialists, whose prosperity is linked up with that of the shipbuilding industry, have had so lean a time of late that they were pleased to find that at the annual meetings of the Institution of Naval Architects the opinion was expressed that the industry is at last beginning to recover. They note that additional merchant ships are to be laid down in British yards, and trust that further orders will be secured so that they, in turn, may be lifted out of the "slough of despond" which has almost enveloped them. When demands for shipbuilding material become normal the iron and steel trades, too, will be in a very different position to what they are to-day.

Unemployment.

There has been a consistent decease in the number of unemployed in the Midlands during the last three weeks. The present total of 108,564 is 3553 fewer than the previous figure, and fewer by 6223 than the figure given a fortnight ago. There is also a drop in the numbers on short time, the total now shown being 31,816 as against 33,368 a week ago.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

General Outlook.

THERE has been little change in the position or outlook of the iron and steel trades of this district since my last report. On all sides one meets with the same discouraging accounts of the state of business. The position, of course, is one of marking time pending developments from the application already made by Lancashire engineering trade operatives for an increase of £1 a week, and also from the negotiations arising out of the report of the Coal Commission. Until something approaching stability and finality in these matters is reached users of iron and steel will continue to carry on their buying operations on a restricted scale. The coming Easter break has made the iron and steel markets even more featureless during the last few days than they were. Many engineering works are closing down for a longer period than they would normally do if the state of their order books were healthier, and in not a few instances it will be well on into next week before work is restarted.

Non-ferrous Metals.

The demand locally for non-ferrous metals is on a limited scale, and the downward tendency of prices

[11] For a fuller description of the type of engine referred to see THE ENGINEER for October 2nd, 1925, and for a description of its application to rail cars on the Canadian National Railways see THE ENGINEER for October 23rd, 1925.—ED. THE E.

generally is not conducive to extended buying operations. Copper values throughout the past week have displayed lack of strength, and at the time of writing a still further weakening of prices is still to be observed. The restricted demands from consumers is playing an important part in the movements of this market, and at the present levels copper is about as low as it has been at any time during the past two months. Cable makers have been operating to some extent, but their purchases have been much below normal. Tin, also, has upset a good many calculations as to the continuance of very high prices, weak sellers having brought values down considerably during the past week. The position is, of course, a highly speculative one, but the view has been expressed on this market that when the present outside influences have run their course, a period of firmer prices may be looked for again. Spelter has been about the steadiest section, although even here values have lost some ground. Lead continues weak and local consumers have been taking only moderate quantities.

Iron.

There has been little activity in the market for pig iron and manufactured iron. Producers report little fresh inquiry of any importance, and what business has actually been booked during the week has been relatively unimportant, certainly too small in the aggregate to make up for the orders which the furnaces are completing. Under present conditions consumers seem to be reluctant to enter into new contracts, and most of the current demand is to fill early needs. In the meantime, Derbyshire, Lincolnshire and Staffordshire No. 3 are all round 76s. per ton, delivered Manchester or equal, with 75s. mentioned in some cases. Scottish No. 3 is in the neighbourhood of 94s., with West Coast hematite on offer at 93s. to 94s. per ton, delivered in both cases. Forge iron is nominally at 72s. to 73s. per ton, delivered, for Derbyshire and Lincolnshire makes, but one does not hear of much important business being done in this material. Manufactured iron is quiet, and the demand for bars both for home use and for shipment is only very moderate. Makers, however, do not admit of any grounds for lower prices, which are maintained at £11 10s. per ton delivered Manchester or equal for Lancashire Crown bars, and £10 5s. per ton for second quality.

Steel.

Most of the demand for steel here during the past few days has been for small parcels, and I can trace virtually no inquiries for big lots since my last report. The announcement of the re-establishment of controlled prices for plates and sections by the Associated Steelmakers is interesting news, and substantiates what has been said in this column in the course of the last week or two of the low prices which some sellers were disposed to accept for any orders that were to be picked up. At the same time the prices now fixed—£7 for sections and £7 10s. per ton for plates—are rather below the rates that have been quoted on 'Change here for some weeks, although, of course, in the absence of a sufficient volume of business to test them they have been regarded as more or less nominal. Ship and tank plates have been quoted here at £7 12s. 6d. to £7 15s., joists and angles at £7 to £7 2s. 6d., and steel bars at £7 17s. 6d. to £8 5s. per ton, delivered Manchester. Little fresh buying of galvanised sheets for India has been reported on this market, and quotations are on the easy side at £15 15s. per ton f.o.b., for the usual specifications, while the Far Eastern demand for thin gauges at the lower prices has also been slow. There has again been only a limited inquiry for foreign steel, and business actually done has been on a small scale. Belgian iron, delivered in the Manchester area for cash against documents, is now quoted at £6 7s. 6d. to £6 10s. per ton; sheet bars are at about £5 7s. 6d.; ordinary billets, £5 5s.; steel bars, £6 4s.; joists and sections, £5 15s.; Siemens' plates, £6 15s.; and ordinary plates, £6 7s. 6d. to £6 10s. per ton.

Scrap.

There is still an absence of much movement in the markets for iron and steel and non-ferrous metal scrap. Prices have an easy tendency, although in many cases they are nominally unchanged. Best selected gun-metal scrap is on offer at about £53 per ton; braziery copper at £48; clean light copper at £57 10s.; heavy copper at £60; lead, £30 10s.; zinc, £35; aluminium, £80 to £90; and brass rod turnings at about £40, for graded qualities, delivered to users' works. Mild steel scrap is quoted at about 55s. per ton on truck; machinery cast iron scrap at 70s.; textile machinery scrap at 72s. 6d. to 75s.; and wrought iron scrap at about 65s. per ton delivered.

Manchester Association of Engineers.

At the annual meeting of the Manchester Association of Engineers, held on Friday last, Sir Benjamin Longbottom, M.I. Mech. E., M. Inst. E.E., was elected president for the ensuing year. Sir Benjamin is the managing director of the Manchester firm, Electromotors, Ltd. The new members of the Council who were elected at the same meeting were:—Messrs. Harold Adamson, H. S. Asbridge, W. W. Millington, E. Oakden, J. H. S. Widdowson, and W. J. Smith. The report for the past year shows that the financial position of the Society has been considerably improved during that period, and that the membership has been well maintained.

Hydro-electric Engineering.

"Hydro-electric Engineering" was the subject of a paper read before the Manchester Association of Engineers on Friday, 26th ult., by Mr. P. W. Seewer, D.E. (Zurich). The author gave some interesting statistics regarding the use and development of water power all over the world. Starting with Switzerland, he said that that country had by far the greatest power per square kilometre, namely, 21 horse-power, or 57 horse-power per square mile; Norway followed with 4·36 horse-power per square kilometre; Italy had 3·7 horse-power per square kilometre; and Japan, 3·61 horse-power. In relation to population, however, it was pointed out that Norway stood at the head of the list, with 51 horse-power per 100 persons, whereas Canada only produced 31 horse-power per 100 persons. The figures for Switzerland and Sweden were 22 horse-power and 30 horse-power respectively. The author said that the British Government had recognised the importance of hydro-electric development to the extent of affording considerable help to the development of new schemes by means of the Trade Facilities Act. He said that with regard to both finance and means of manufacture this country possessed resources which were practically unknown elsewhere, especially on the Continent. During the last two years British water power engineers had dealt with schemes amounting to more than half a million horse-power. By means of the lantern the author gave a number of illustrations of some of the largest hydraulic turbines in existence, including one of 30,000 horse-power built for the Tata Engineering Company, Bombay, a machine which operates under a head of 1650ft.

The Engineers' Club, Manchester.

At the annual general meeting of the Manchester Engineers' Club, held on Tuesday, 30th ult., Alderman F. J. West, M.I. Mech. E., Deputy Lord Mayor of the city, was re-elected president for the ensuing year; Mr. J. Owden O'Brien was re-elected honorary treasurer; and Mr. H. Richardson honorary secretary. The new members of Committee elected were Mr. J. Cartland and Mr. H. C. D. Scott. It was agreed to make an alteration in the rules of the Club to enable the sons of members possessing the necessary qualifications to be admitted to membership upon reaching the age of twenty-two.

Barrow-in-Furness.

Hematite.

The hematite pig iron trade on the West Coast is quiet but steady and very little is going into stock owing to the fact that the steel departments are taking a fair proportion of the output. There are no new features in the market at all, and many of the customers are content at present to place orders only for immediate requirements, leaving orders for forward delivery until such time as industrial conditions generally are more settled. It seems certain that the coal trouble is casting a shadow on the trade, but not to the extent that some people would make out. The demand would improve, it is certain, if the horizon were clear, but not to the great extent some forecast. It would probably mean the placing of more orders for forward delivery, and thus the maker would have a better grasp of trade than he has at present. Overseas trade is quiet. Orders for special and semi-special qualities are being placed, but not to any great extent.

Iron Ore.

The iron ore trade remains quiet, and will continue in that condition until there is an improvement in the iron trade of the district. The local activity in ore is wholly dictated by the iron trade, as very little is going out of the district. Foreign ore is being bought in moderate quantities.

Steel.

The general tone in the steel trade is one of moderate quietness, there being insufficient orders to keep the two works in the district on full time. Barrow has its rail, Siemens, merchant, hoop, and small sections mills working, but Workington has not sufficient orders to keep the rail, sleeper and merchant mills going all the time.

SHEFFIELD.

(From our own Correspondent.)

State of the Steel Trade.

There is no improvement to record in the condition of the heavy steel trades of this district. The call for billets for ordinary commercial purposes is still on an unsatisfactory scale, and the first quarter of the year has been a cheerless time for the majority of firms. Figures of output for January show that the production of steel ingots and castings in the area amounted to 83,100 tons, which included 30,500 tons of acid and 49,400 tons of basic. The total was 7000 tons higher than in December, but 8000 tons less than in January of last year. The Lincolnshire production, all basic, was 34,900 tons, which was 1000 tons better than December, but 5000 tons below the figure of January, 1925. Optimism as to the future is not dead; in fact, many people consider that the undertone is improving. The shipbuilding industry is showing more signs of life, though they are slight at present. Good reports continue to be received of the electrical industry, which is doing well in spite of foreign competition. The British Engineers' Association, in its monthly bulletin, states that the export figures have maintained the favourable, though slight, improvement of recent months.

Railway Steel.

Mr. W. L. Hichens, Chairman of Cammell Laird and Co., Ltd., speaking at the annual meeting of the company last week, held out little hope of an improvement in trade during the present year. "Frankly, he said, "I think it will probably be worse on the whole. Orders are still scarce, especially in shipbuilding; prices are lower than ever, there will be practically no armour plate orders, while a dark cloud of uncertainty is hanging over us as regards the labour situation." Mr. Hichens did, however, express the hope that the railway carriage and wagon side of the business would show a material improvement, and, referring to the subsidiary undertaking of the Leeds Forge Company, he said that it was making a marvellous and rapid recovery, and there was every reason to think that the results of the reorganisation would be apparent in next year's balance sheet. The making of railway supplies is still one of the busiest branches of the heavy steel trade. Large orders are on hand from the home railway companies, but the quantity of work coming from overseas is unsatisfactory. Prices keep low. John Baker and Co., Ltd., of Rotherham, report that the hopeful prospects apparent at the opening of 1925 did not materialise. During the greater part of the year there was little demand for railway and tramway rolling stock, while foreign and home competition was very keen, and prices were consequently low and in many cases unremunerative. The year's working resulted in a surplus of upwards of £10,000.

Tramway Track Orders.

The Titan Trackwork Company, Ltd., Sheffield, has secured an order for a large double-track triangular tramway junction for Shanghai. This and several other large orders for this trackwork, which is manufactured from S. Osborn and Co.'s Titan magnanese steel, have—says the bulletin of the British Engineers' Association—been secured in the face of the keenest foreign competition. The same company has also booked a contract for two large Liverpool tramway junctions, one of which forms a portion of the busy pier-head lay-out.

The Lighter Branches.

The works supplying stampings and steel for automobile purposes are among the busiest on the lighter side of the steel industry. They had a shock last week when a large British motor car firm, which has recently announced a reduction of 15 per cent. in the selling price of its cars, sent round a circular stating that it expected that the firms with which it does business will make a similar reduction in the price of the material supplied by them. The suggestion has not been at all welcomed in Sheffield, and a representative of one of the firms concerned has expressed the opinion that Sheffield manufacturers are already selling on rock-bottom prices, and that they dare not cut any more. The business generally, although on a substantial scale, is not very remunerative from a profit-making point of view. A great amount of slackness still exists in edge tools, hand and circular saws, engineers' small tools and files. A moderately good demand is reported for farm and garden tools. Cutlery and plate continue as depressed as my recent letters have shown. The trade in safety razor blades continues busy, and an additional plant has been started during the last week.

Russian Disappointments.

One of the improving features of Sheffield trade during the last two or three years has been the partial recovery of business with Russia, which country has taken increasing quantities of saws, files, tools, tool steel and other products. The trade did not by any means regain its old level, but it was sufficient to provide a welcome amount of activity for several firms. It has generally fallen off towards the end of each year, owing to the closing of the ports, but has been resumed early in the new year. This year, however, the resumption has not taken place, and much disappointment is felt. Several reasons are advanced for the altered state of things. One is considerations of credit; another, that the Russian policy of buying seems to be in a condition of transition; a third, that the Russian winter has been exceptionally severe, with the consequence that there is not a sufficient volume of exports to set off the value of imports. Whatever the cause, some Sheffield firms have not booked a Russian order since last October, and, of the few orders that have been received in this country for machine tools, stocks and dies, only a small proportion has come to this city. It is fully expected, however, that the business will come along at a later date, and that it will be of large proportions.

A Hint to the Cutlery Trade.

Mr. J. C. Ward, a director of Edgar Allen and Co., Ltd., in his address last week on retiring from the presidency of the Sheffield Chamber of Commerce, referred to the future of the cutlery trade. In no branch of local industry, he said, was the stimulus of keen competition being more severely felt than in cutlery. Useful work was being done by the British Cutlery Research Association, and it was hoped that it would bear fruit; but, without wishing to dictate to the cutlery manufacturers, he would like to express the opinion that their future policy, if success was to come to them, must be bolder in character than had hitherto been the case. Their equipment and methods would need to be thoroughly modernised to meet the demands of the situation, and it might be necessary for them, as had been suggested in other quarters, to reduce the number of their patterns and set out to capture the big trade rather than the small orders that could not be produced at profitable prices.

New Chamber of Commerce President.

The new President of the Chamber of Commerce is Mr. J. H. Chapman, a director of Ibbotson Brothers and Co., Ltd., one of the leading steel firms of the city, with which he has been connected for more than fifty years. Mr. Chapman has travelled much in various parts of Europe, and is a most competent and accomplished linguist. In the latter capacity he has been of great service to the Chamber, having given translations of letters and documents sent in French, Spanish, Portuguese, Italian, Russian, German, Dutch and Flemish.

New Road to the North.

The Wortley Rural Council has decided to make an early start with the construction of an important new road from High Green to Birdwell, which will open up a new through route between Sheffield, Barnsley and the North, and will obviate the use of dangerous hills and curves on the present main road. Sufficient land is being purchased to allow of a width of 80ft. between the fences. The estimated cost is £128,500, towards which the Unemployment Grants Committee will contribute 75 per cent. of the interest and sinking fund charges.

Retford Electricity Contracts.

The Town Council of Retford has decided to enter upon an electricity scheme, for the preparation of which definite steps have now been taken. The gas supply, which is municipally owned, is to be the basis of the generation of electric current, and it is hoped that the supply will, in the near future, be supplemented by surplus current

from neighbouring collieries. The Town Council last week accepted the following tenders :—Section B, underground mains, the Pirelli General Cable Works, Ltd., £9275 18s. 4d.; Section C, transformers and control gear, the Foster Engineering Company, £2516; Section D, consumers' meters, Measurement, Ltd.

Colliery Matters.

At the annual meeting of the Hoyland Silkstone Coal and Coke Company, the chairman stated that the screening and picking arrangements at the colliery have been entirely replaced by up-to-date machinery. A complete reorganisation of the winding and other plant is under consideration, but in view of the conditions, political and industrial, now obtaining in the country, it is doubtful if the expenditure entailed is justifiable. The colliery lost £63,000 on last year's working, largely owing to adverse trading conditions, but the chairman stated that the directors had complete confidence in the intrinsic soundness of the concern. The quality of the coal seams was excellent, and the surface arrangements which were nearing completion, and which dealt with the picking and screening of the coal, were now producing excellent qualities of fuel At Rossington, one of the rapidly developing villages in the Doncaster colliery area, a Ministry of Health inquiry has been held into the application of the Doncaster Rural Council to borrow about £7000 for sewage disposal works.

NORTH OF ENGLAND.

(From our own Correspondent.)

Disappointed Hopes.

THREE months of 1926 have now been added to the lengthening history of the iron and steel trade's struggle against adversity. It has been a period of disappointment and of hopes unrealised. The year opened with a confident note, and it is a fact that the total tonnage sold under forward contracts reached a very high figure. Indeed, the position improved to such an extent that four additional blast-furnaces were soon put into operation on the North-East Coast. But the markets have lapsed again into apathy. The factors contributing to this unsatisfactory state of affairs are the approach of the Easter holidays, disquieting reports from abroad, and the uncertainty in the coal trade. An essential condition of any revival of business activity is a settlement of the coal crisis, and on that account the negotiations proceeding between the Government, the minowners and the miners are being followed with grave anxiety. It would be a mistake, however, to adopt an altogether pessimistic view of the outlook. There is a good undertone, and it is generally felt that when the problems facing the coal trade are satisfactorily solved, the industrial position will quickly improve.

Cleveland Iron Trade.

Business in the Cleveland pig iron trade this week has continued on quiet lines. Both makers and buyers, however, are still very reluctant to commit themselves, and the few actual sales that are recorded are confined to small quantities to cover immediate requirements. A serious factor is the increased continental competition. Producers abroad are able to lower their quotations as a result of rate of exchange movements, and the outlook in this respect is somewhat discouraging. Makers in this district complain that ruling quotations leave no margin of profit, and declare that a fall in prices would be speedily followed by plants being laid idle. The strength of the statistical position enables makers to adhere to quotations which have been ruling for some time past. They have very small stocks, and they have a fair amount of work on hand. The following are the home prices of Cleveland iron :—No. 1 foundry, 72s. 6d.; No. 3 G.M.B., 70s.; No. 4 foundry, 69s.; No. 4 forge, 68s. 6d.; mottled and white iron, 68s. Export prices are in all cases 6d. per ton more than the foregoing.

Hematite Pig Iron.

There are no new features of moment in the East Coast hematite pig iron trade. Being already below the cost of production, makers are reluctant to cut prices further, but the demand is sluggish, and it is reported that 77s. has been shaded for mixed numbers, though that is still the general market quotation, with No. 1 at 77s. 6d. per ton.

Ironmaking Materials.

There is very little business passing in the foreign ore trade, sales being almost entirely confined to odd cargoes. Consumers are carrying heavy stocks, and some of them have still substantial supplies to take up against old contracts. Nominally, best Rubio ore remains at 21s. 3d. per ton c.i.f. Tees. Supplies of Durham blast-furnace coke continue ample. Good average qualities are quoted 19s. to 19s. 6d. per ton delivered at the works.

Manufactured Iron and Steel.

Conditions in the manufactured iron and steel trade show little or no improvement. In many cases manufacturers have great difficulty in keeping their plant in operation. Continental firms have been pressing parcels of semi-finished materials on this district, but actual business has apparently not been extensive. Demand for finished steel is quiet. Some hope of trade expansion is aroused by the placing of more orders for new ships, but many more contracts must be arranged before shipyards can return to anything like a normal basis. Ship plates, however, have moved up half-a-crown, and now stand at £7 10s. per ton. Other prices remain practically unchanged.

Ironworkers' Wages Advanced.

The official accountants have certified that the average selling price of manufactured iron in the North of England for the first two months of the year was £11 19s. 2.66d. per ton, as compared with £11 15s. 5.85d. per ton in the previous two months. Accordingly, under the sliding scale arrangement, there will be an advance of 2½ per cent. in puddling and other forge and mill wages as from March 29th.

The Coal Trade.

The Northern coal trade shows no appreciable change on the week. The inquiry continues very feeble. Buyers have not shown any inclination to negotiate beyond pressing needs, and consequently cargoes for prompt shipment have represented most of the trade. There is, of course, a considerable quantity of coal moving on contract account, and it is this that keeps the pits at work. Fitters are mainly concerned with keeping their collieries going from day to day, and are consequently accepting prices for spot clearances at lower figures than market quotations. The prospect for April is none too bright. There will not be any short time, but fitters are uncertain how they will be situated later in the month. The negotiations proceeding between the coalowners' and miners' representatives are causing a certain amount of concern to operators, but on the whole a favourable settlement is regarded as likely, and consequently shippers show no anxiety as to forward supplies. Good stemming positions are recorded for Northumberland steam coals. Fitters quote steadily at 17s. for best Blyth steams, and even second-hand offerings of fuel are not large at 16s. 6d. Other first-class steam coals are quiet at 15s. to 15s. 6d., with secondary grades at 14s. to 14s. 6d. Best steam smalls are steadier following upon rather improved bookings, and sellers ask 8s. to 8s. 6d. Tyne prime smalls and other special makes are holding up to 10s. to 10s. 6d., and seconds to 7s. 6d. In the Durham market, best gas coals are maintained at 17s. 6d. to 18s., and prices tend to become firmer. Seconds are in no pressure of supply at 14s. 6d. to 15s. Little business matures in coking coals, and supplies are ample. The coke trade is represented by only small placings, and, with a consequent excess of output, prices of all makes are but weakly held.

SCOTLAND.

(From our own Correspondent.)

Rapid Construction.

SEVERAL records have been made during the course of construction of the steamer Nerissa, which will be launched this week at Port-Glasgow. The contract for the Nerissa was signed on November 3rd. The keel was laid in seven days; the framing was completed within 57 days, and the plating in 112 days from the time she was laid down. The steamer will be launched within five months of the signing of the contract. The Nerissa is a passenger and cargo vessel of 5500 tons gross, built by William Hamilton and Co., Port-Glasgow, for the Newfoundland service of the New York, Newfoundland and Halifax Steamship Company (the Red Cross Line). This vessel has an ice-breaker bow, a reinforced stern, and well furnished accommodation for 160 first-class and 60 second-class passengers.

Pig Iron.

The pig iron market is still inactive, and producers have practically nothing of fresh interest to report. Consumers in general are not disposed to increase commitments in the meantime, and with buying confined to actual requirements, the total turnover is less than the present restricted output. Prices are fairly steady, but can hardly be termed firm.

Steel Sheets.

The present demand for black and galvanised sheets of the light variety has greatly exceeded expectations, and some makers are overwhelmed with orders. In fact, it has been stated that orders have been refused, owing to the impossibility of delivery within the specified period. Heavy sheets are not so busy as the light varieties, but are fairly well placed, despite competition from steel plates.

Steel and Iron.

The scarcity of specifications for steel plates and sections is still very much in evidence, and the turnover is mostly of a hand-to-mouth character, especially for sections. Prices are inclined to ease further in spite of the fact that present levels are not very remunerative. Bar iron is disappointing. Orders are scarce all round, and considerable price cutting has been indulged in of late in connection with export inquiries. Home quotations are virtually unchanged. Re-rolled steel is only in moderate demand, and here again prices are subject to fluctuation, more especially when export orders are in prospect. In common with other materials, the demand for scrap is extremely modest and business is featureless.

Coal.

The coal market in general continues dull in tone. In spite of negotiations which have already been reported, there is an absence of confidence with regard to the future, and business is extremely difficult to conclude. Foreigners are most sparing in their orders, and second-hand fuel is freely offered, as holders find extreme difficulty in disposing of the coal they have contracted for. Prices are weakening all round, with the exception of splints, which are well booked up for shipment to the Mediterranean and South America. As a rule, however, most descriptions are easily procurable on terms very advantageous to buyers, as many pit sidings are congested with loaded wagons. Broken time at the collieries is fairly general at the moment.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Conditions.

VERY active conditions prevail in the steam coal industry, that is so far as shipments are concerned. At the end of last week there were thirteen idle loading berths at the various docks, but of that number seven were at Swansea, where shipments of anthracite are rather restricted for the time being. As against the number of idle loading appliances there were seventeen steamers waiting, of which nine were at Cardiff, five at Barry and one at Newport. Arrivals of tonnage over the week-end have improved the position, so that the colliery companies have a good supply of tonnage and a ready outlet for their coals. There is evidence all round of strenuous efforts being made to load and sail tonnage before the holidays, and the difficulty of obtaining fresh supplies of coal for prompt loading is shown by the jumpy state of the market, which is very firm, especially for small coals. At the moment no new inquiry is on the market in respect of a large quantity of coals, with the exception of the requirements of the Egyptian State Railways, which amount to 150,000 tons of locomotive qualities and are for delivery from June to August. The tenders have to be in at Cairo on April 21st, but exporters feel that they are in a quandary in view of the extremely unsettled outlook, and there is already talk on the market that a number of firms which usually quote for this business are not prepared to do so on this occasion on account of the extreme risk attached to the order on the present occasion. Of course, it may be that the air will be cleared to some extent by the middle of April, but very few appear to be optimistic in this respect, and fear that the present uncertainty will be maintained right up to the last minute. It is admitted that the Government is doing its best to assist towards a settlement, but exactly how far apart the parties actually are has yet to be disclosed. The feeling is entertained that much valuable time is being lost by the parties to the issue waiting for each other to move. Hopes are held, however, that the current week will see them declare exactly where they stand, so that immediate steps can be taken to bridge the gulf between them.

Easter Holidays.

Mention has already been made that there will be no work in this coalfield during the first three days of next week. The position so far as the trimmers and tippers is that an agreement has been come to that work should cease at 10 p.m. on Thursday—April 1st—until 6 a.m. on Saturday morning, and that work shall again be suspended from twelve noon that day until Wednesday, April 7th, when the normal working hours will be resumed.

Docks Appointments.

Mr. E. Lowther has resigned his appointment as chief docks manager of the Great Western Railway Company as from April 30th, and he will be succeeded by Mr. C. S. Page, who is the present assistant docks manager. Mr. Lowther was formerly the chief goods manager of the company. On the absorption of the Port Talbot Railway and Docks Company, Mr. Lowther was appointed in June, 1921, as chief docks manager. Since then he has done very valuable work in improving the loading and discharging facilities for coal and all classes of general cargo. His successor, Mr. Page, has been assistant chief docks manager since May, 1922, and prior to that was assistant general manager of the Cardiff Railway.

Reservoir Construction Stopped.

Consternation has been caused in Cardiff by the decision of the Cardiff City Council, sitting on Monday as a General Purposes Committee, to suspend work on Wednesday of this week on the Wenallt Reservoir. So far about £105,000 has been expended on this project, the reservoir being constructed to have a capacity of fifteen million gallons and about £42,000 is required to complete the scheme. Geological disturbances on the floor of the reservoir were discovered at the end of January, rendering it difficult to make the reservoir watertight. Some of the members of the Council hold the view that the money already spent has been thrown away, but the chairman of the Waterworks Committee does not agree. The Committee shares his view that it will be wise, having discovered these subsidences, to suspend operations until the work of full exploration has been carried out. Their experts will not commit themselves now. Subsidence has not been found under the walls, but in the middle of the reservoir. The General Purposes Committee approved of the agreement arrived at between the sub-committee and the contractors, so that the work finishes on Wednesday of this week for at least six months, and the net loss on the closing of the contract is £14,421.

Pit Re-opening.

The Tillery Pit, Abertillery, which employed 900 men under normal conditions, is to re-open immediately. This is one of a group of three collieries which were closed down on account of trade depression in October, 1924.

Tenders Accepted.

The Cardiff Electricity Committee has accepted the tender of Fraser and Chalmers, of Erith, for a new 10,000-kilowatt turbo-alternator at the price of £31,301. Condensing plant is to be supplied by Cole, Marchent and Morley, of Bradford, their tender being £6791, and dust collectors required for the power station by Davidson and Co., Ltd., of Belfast, at the price of £1600.

Current Business.

Although there has been no rush of orders on the market, still there is a fair demand for prompt supplies, in many cases for the purpose of completing cargoes of steamers already in dock, and the result is that with colliery companies so fully stemmed the conditions all round are very firm. This is more particularly the case with small coals, the price being up to 15s. for best descriptions. Naturally collieries have rather advanced ideas as to values for next month, and in many instances they are not quoting at all, as already they have pretty full order books. Patent fuel and coke are also stronger, and anthracite coals are a shade steadier. Pitwood continues to recover, and is 25s. 6d. to 26s.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. Coast—	
Native	21/-
(1) Spanish	18/6
(1) N. African	18/6
N.E. Coast—	
Native	—
Foreign (c.i.f.)	21/3

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) Scotland—		
Hematite	3 17 0	—
No. 1 Foundry	3 19 0 to 4 1 6	
No. 3 Foundry	3 16 6 to 3 19 0	
N.E. Coast—		
Hematite Mixed Nos.	3 16 6	3 16 6
No. 1	3 17 0	3 17 0
Cleveland—		
No. 1	3 12 6	3 13 0
Silicious Iron	3 12 6	3 13 0
No. 3 G.M.B.	3 10 0	3 10 6
No. 4 Foundry	3 9 0	3 9 6
No. 4 Forge	3 8 6	3 9 0
Mottled	3 8 0	3 8 6
White	3 8 0	3 8 6
Midlands—		
(3) Staffs.—		
All-mine (Cold Blast)	10 10 0	—
North Staffs. Forge	3 17 6	—
,, ,, Foundry	4 7 6	—
(3) Northampton—		
Foundry No. 3	3 3 0 to 3 4 6	
,, Forge	2 16 0 to 2 17 0	
(3) Derbyshire—		
No. 3 Foundry	3 6 0 to 3 7 0	
Forge	3 0 0 to 3 2 0	
(3) Lincolnshire—		
No. 3 Foundry	3 8 0	—
No. 4 Forge	3 5 6	—
Basic	3 6 0	—
(4) N.W. Coast—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 10 0 (a) / 4 12 6 (b) / 4 17 6 (c)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
Scotland—		
Crown Bars	11 5 0	—
Best	—	—
N.E. Coast—		
Common Bars	11 0 0	—
Lancs.—		
Crown Bars	11 10 0	—
Second Quality Bars	10 5 0	—
Hoops	14 0 0	—
S. Yorks.—		
Crown Bars	12 10 0	—
Best ,,	13 10 0	—
Hoops	14 10 0	—
Midlands—		
Crown Bars	11 0 0 to 12 0 0	
Marked Bars (Staffs.)	14 0 0	—
Nut and Bolt Bars	10 5 0 to 11 0 0	
Gas Tube Strip	12 10 0	—

STEEL.

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) Scotland—		
Boiler Plates	11 0 0	—
Ship Plates, ½in. and up.	7 7 6	—
Sections	6 17 6	—
Steel Sheets, under 3/16in. to ½in.	9 0 0	—
Sheets (Gal. Cor. 24 B.G.)	—	£17 to £18

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. Coast—		
Ship Plates	7 10 0	—
Angles	7 0 0	—
Boiler Plates	11 10 0	—
Joists	7 0 0	—
Heavy Rails	8 0 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5
Hard Billets	8 2 6	—
Soft Billets	7 5 0	—
N.W. Coast—		
Barrow—		
Heavy Rails	8 0 0†	—
Light ,,	8 5 0 to 8 10 0	
Billets	7 10 0 to 9 0 0†	
Manchester—		
Bars (Round)	8 0 0 to 8 5 0	
,, (others)	8 0 0 to 8 5 0	
Hoops (Best)	13 5 0	13 0 0
,, (Soft Steel)	10 0 0	9 15 0
Plates	7 15 0	—
,, (Lancs. Boiler)	11 10 0	—
Sheffield—		
Siemens Acid Billets	10 10 0	—
Bessemer Billets	11 5 0	—
Hard Basic	8 12 6	—
Intermediate Basic	8 2 6	—
Soft Basic	8 15 0	—
Hoops	12 0 0	—
Soft Wire Rods	9 10 0	—
Midlands—		
Small Rolled Bars	7 15 0 to 8 0 0	
Billets and Sheet Bars	6 0 0 to 6 2 6	
Sheets (20 W.G.)	11 10 0 to 12 0 0	
Galv. Sheets, f.o.b. L'pool	15 17 6 to 16 5 0	
Angles	7 0 0	—
Joists	7 0 0	—
Toes	8 0 0	—
Bridge and Tank Plates	7 15 0	—
Boiler Plates	11 0 0 to 11 10 0	

NON-FERROUS METALS.

Swansea—	
Tin-plates, I.C., 20 by 14	19/3 to 19/6
Block Tin (cash)	282 10 0
,, (three months)	275 7 6
Copper (cash)	57 2 6
,, (three months)	58 0 0
Spanish Lead (cash)	31 12 6
,, (three months)	31 16 3
Spelter (cash)	33 17 6
,, (three months)	34 2 6
Manchester—	
Copper, Best Selected Ingots	62 15 0
,, Electrolytic	65 15 0
,, Strong Sheets	90 0 0
,, Tubes (Basis Price)	0 1 1
Brass Tubes (Basis Price)	0 1 0
,, Condenser	0 1 2½
Lead, English	30 15 0
,, Foreign	30 6 3
Spelter	33 6 3 to 33 7 6

FERRO ALLOYS.

(*All prices now nominal.*)

	Per Ton.	Per Unit.
Tungsten Metal Powder	2/1 per lb.	
Ferro Tungsten	1/9½ per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£22 10 0	7/6
,, 6 p.c. to 8 p.c. ,,	£22 0 0	7/3
,, 8 p.c. to 10 p.c. ,,	£20 15 0	6/6
,, Specially Refined		
,, Max. 2 p.c. carbon	£38 10 0	12/6
,, ,, 1 p.c. ,,	£44 10 0	15/-
,, ,, 0·70 p.c. carbon	£54 10 0	17/6
,, ,, carbon free	1/5½ per lb.	
Metallic Chromium	3/3 per lb.	
Ferro Manganese (per ton)	£15 for home, £15 for export	
,, Silicon, 45 p.c. to 50 p.c.	£11 15 0 per unit	scale 5/- per
,, ,, 75 p.c.	£20 10 0 per unit	scale 6/- per
,, Vanadium	14/6 per lb.	
,, Molybdenum	6/- per lb	
,, Titanium (carbon free)	0/11½ per lb.	
Nickel (per ton)	£170	
Cobalt	10/- per lb.	
Aluminium (per ton)	£112	

FUELS.

SCOTLAND.

	Export.
Lanarkshire—	
(f.o.b. Glasgow)—Steam	15/6
,, ,, Ell	15/-
,, ,, Splint	16/6 to 19/6
,, ,, Trebles	15/3
,, ,, Doubles	13/3
,, ,, Singles	12/9
Ayrshire—	
(f.o.b. Ports)—Steam	15/6
,, ,, Jewel	16/6
,, ,, Trebles	15/6
Fifeshire—	
(f.o.b. Methil or Burntisland)—Steam	12/7½ to 15/-
Screened Navigation	21/-
Trebles	14/- to 15/-
Doubles	12/9
Singles	12/6
Lothians—	
(f.o.b. Leith)—Best Steam	14/-
Secondary Steam	13/3
Trebles	14/3
Doubles	13/-
Singles	12/3

ENGLAND.

(8) N.W. Coast—	
Steams	24/-
Household	40/- to 48/-
Coke	26/-
Northumberland—	
Best Steams	16/3 to 17/-
Second Steams	14/- to 14/6
Steam Smalls	8/- to 8/6
Unscreened	13/- to 13/6
Household	20/- to 22/-
Durham—	
Best Gas	17/6 to 18/-
Second	14/6 to 15/-
Household	20/- to 22/-
Foundry Coke	18/- to 20/-
Sheffield—	Inland.
Best Hand-picked Branch	31/- to 34/-
Barnsley Best Silkstone	28/- to 30/- —
Derbyshire Best Brights	26/- to 28/- —
,, ,, House	24/- to 25/- —
,, ,, Large Nuts	17/- to 20/- —
,, ,, Small	12/6 to 14/- —
Yorkshire Hards	17/- to 19/6 —
Derbyshire ,,	16/- to 19/- —
Rough Slacks	10/- to 12/6 —
Nutty ,,	7/6 to 9/- —
Smalls	3/6 to 6/- —
Blast-furnace Coke (Inland)*	— —
,, ,, (Export) f.o b.	16/- to 17/-

(9) SOUTH WALES.

Cardiff—	
Steam Coals:	
Best Smokeless Large	23/6 to 24/6
Second ,, ,,	22/- to 23/-
Best Dry Large	22/- to 24/-
Ordinary Dry Large	19/6 to 20/6
Best Black Vein Large	21/6 to 22/-
Western Valley Large	20/6 to 21/-
Best Eastern Valley Large	20/6 to 21/-
Ordinary ,, ,,	19/- to 20/-
Best Steam Smalls	14/- to 15/-
Ordinary ,,	12/- to 13/6
Washed Nuts	19/- to 26/-
No. 3 Rhondda Large	26/6 to 27/-
,, ,, Smalls	16/- to 16/6
No. 2 ,, Large	19/6 to 20/6
,, ,, Through	16/6 to 18/6
,, ,, Smalls	10/6 to 11/6
Foundry Coke (export)	40/- to 50/-
Furnace Coke (export)	25/- to 30/-
Patent Fuel	21/- to 22/6
Pitwood (ex ship)	25/- to 25/6
Swansea—	
Anthracite Coals:	
Best Big Vein Large	39/- to 40/-
Seconds	30/- to 32/6
Red Vein	27/- to 29/-
Machine-made Cobbles	50/- to 52/6
Nuts	50/- to 52/6
Beans	40/- to 42/6
Peas	21/- to 24/-
Breaker Duff	6/- to 7/-
Rubbly Culm	11/- to 11/3
Steam Coals:	
Large	22/- to 23/-
Seconds	20/- to 22/-
Smalls	9/- to 10/-
Cargo Through	16/- to 17/-

(1) Delivered. (2) Net Makers' works. (3) f.o.t. Makers works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire, and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. * For blast-furnaces only, 17/-, with fluctuations according to analysis; open market, 17/6 to 19/- at ovens. † Latest quotations available. (*a*) Delivered Glasgow. (*b*) Delivered Sheffield. (*c*) Delivered Birmingham.

French Engineering Notes.

(From our Correspondent in Paris.)

Currency Depreciation.

In all branches of trade and industry a very gloomy view is being taken of the situation which has been created by the further sensational fall of the franc. It is true that a fair volume of business is being transacted, because there is always work to be done, but activity is slowing down all round, and no one knows whether he is making profit or not. The fall in the value of the franc means a heavy capital depreciation of all industrial undertakings, and as the workers alone have actually bettered their position, and are earning relatively more than they did before the war, the conditions are not favourable to industrial enterprise. When certain necessaries and raw material have to be purchased from abroad with a currency which is constantly fluctuating, the manufacturer never knows what his costs are likely to be, and having been further increased by recent taxation, those costs are certain to be inflated by the new taxes, which must be imposed if the national finances are to be put into something like order. Nearly all the trouble arises from the way in which the heavier part of the fiscal burden is placed upon traders and manufacturers, while the huge farming class is let off very lightly, and it is partly due to this struggle between rival interests that the financial situation has fallen into an apparently hopeless muddle.

Import Tariffs.

The new Tariff Bill has certainly been the longest of its kind in preparation, and will probably be found eventually to differ entirely from the character of the measure when it was originally drawn up more than three years ago. Each time the Bill was on the point of being introduced into Parliament it had to be temporarily withdrawn, because it was considered that no definite fiscal policy could be adopted while the economic situation was so unsettled. The system of coefficients was deemed to be the only one that could meet the fluctuations of the transition stage. It has serious drawbacks, particularly its changing character, which is always leaving importers in doubt as to what will happen in the early future. It is still doubtful whether the Government will insist upon its proposal to raise the import duties temporarily by 30 per cent., or whether it will give in to the pressure of public opinion and introduce the new Tariff Bill without further loss of time. It is certain that great haste is being made to put the final touches to the Bill, which is distinguished by an elaborate classification of goods and by an extensive adoption of *ad valorem* duties which the French have always regarded as untrustworthy. If such duties are imposed, great care must be taken to insure that the goods are declared at their real value, and the various Chambers of commerce are now being asked to give their opinion upon the method which the Government proposes to adopt for fixing the duties. They are to be imposed upon the wholesale prices in the countries from which the goods are imported, plus the freight and other charges they have to bear when entering France. Each invoice must be certified by a French Consul, and, if required, the exporter of goods to France must produce contracts, orders, correspondence or other documents to prove the accuracy of the invoiced figures. Another question to be debated is whether the duties are to be paid on the basis of gold francs. This is a salient feature of the Bill as drawn up by the Customs Commission, but it is meeting with a certain amount of criticism as likely to provoke retaliation. There appears to be little doubt, however, that the duties will be levied on a gold basis.

Railway Rates.

The railways have always been regarded belonging to those public services which have to be run at the lowest possible cost to users with the idea that when the public can travel cheaply and goods can be conveyed at low rates, the advantages are to the common good. The benefits of cheap transport are obvious if the companies can pay their way, but when enormous deficits have to be made good by the State the low tariffs are illusory, since the public has to pay more in the form of rates. It also subsidises the goods traffic. As the State needs the money for other things than to meet the rapidly increasing deficits due to the higher wages and the advantages accorded to railwaymen, the Government secured the passing of a law in 1921 whereby no more money was to be paid to the railway companies from 1927. They must all pay their way. In Germany and Italy they have been made to do so by a heavy reduction in the number of railwaymen. In France such a drastic measure would be impossible. The only alternative lies in increasing the railway rates, and when that was done at the beginning of the year it was predicted that the country would collapse under the burden. The Minister of Public Works has now produced figures to show that the higher rates have actually been accompanied by a steady increase of traffic and of a proportionately higher revenue, and he states that if further action is needed to balance the railway accounts, he will not hesitate to increase the rates again.

Foreign Trade.

The growing margin of imports over exports continues to emphasise the difficulties that are caused by the monetary depreciation. The purchases of foodstuffs, raw material and manufactured goods are larger, both in quantity and value, and the exports have mostly diminished in quantity. As the steadily improving "balance of trade" observable down to near the end of last year was attributed to the falling value of the franc, the change which has taken place since last November is regarded as inexplicable; but, as a matter of fact, the French agricultural production is so far restricted by the labour scarcity that larger quantities of foodstuffs have to be purchased abroad and from the Colonies, and for raw material much higher prices in French currency have to be paid. During the first two months of the year the imports totalled 7,774,628 tons, an increase of 277,228 tons, as compared with the corresponding period of 1925. The exports amounted to 6,023,074 tons, a diminution of 148,789 tons. The difference in values was much more considerable.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

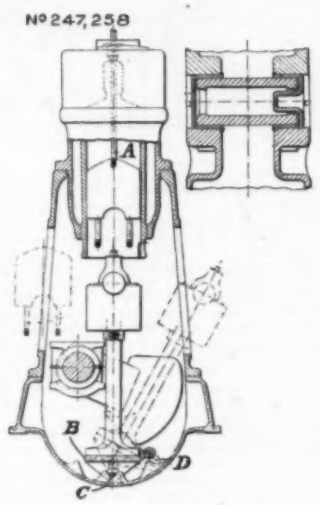
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

247,258. November 5th, 1924.—DISMANTLING OIL ENGINES, O. Wans and Ruston and Hornsby, Ltd., Lincoln.

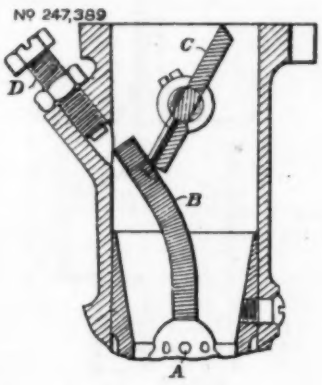
The inventor proposes to facilitate the removal of the running parts of a vertical oil engine by parting the piston on the centre line of the gudgeon pin, as shown in the drawing. In taking down



the engine the upper half of the piston is supported by the screwed rod A. The lower half is then unbolted and lowered, together with the connecting-rod, on to a special pad B. This pad can rock on the two pivots C and D and provides a ready means of tilting the connecting-rod out through the crank case door.—*February 5th*, 1926.

247,389. February 16th, 1925.—CARBURETTERS, C. H. Clandel, 17bis, Boulevard de Levallois Prolongé, Neuilly-sur-Seine, France.

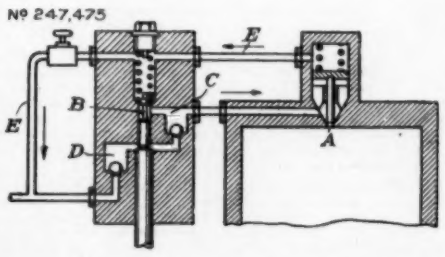
This carburetter has separate jets for normal, full-speed running and for running light. The jets for full power are shown at A and need no comment. The jet for slow running is



situated inside the bottom of the flexible tube B. When the throttle C is closed the tube B is bent over and is embraced by a notch in the edge of the throttle disc, so that the suction of the engine is concentrated on the special jet. The screw D provides a means of adjusting the slow speed of the engine.—*February 18th*, 1926.

247,475. August 18th, 1925.—OIL ENGINE FUEL JETS, F. Lang, 4, Militärstrasse, Stuttgart, Germany.

The real significance of this specification is most obscure, but it appears that the inventor is endeavouring to provide a very quick cut-off in the supply of the fuel oil to the spray A. He

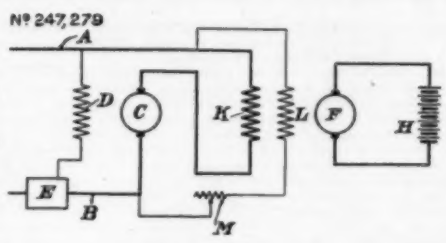


arranges a valve B to make communication between the delivery C and the suction box D of the fuel pump. This valve is forcibly lifted off its seat by an extension of the pump plunger, when the supply of oil to the spraying nozzle will, of course, cease. The pipe E is provided to return leakage oil back to the suction.—*February 18th*, 1926.

DYNAMOS AND MOTORS.

247,279. November 11th, 1924.—IMPROVEMENTS IN OR IN CONNECTION WITH THE CHARGING OF ELECTRIC ACCUMULATORS, John Wesley Burleigh, of Homecroft, Highbridge-road, Burnham-on-Sea, Somerset; and Rotax (Motor Accessories), Ltd.

The object of this invention is to enable the charging of electric accumulators to be effected by a compound-wound generator. In the diagram A B are the supply leads of the motor, C is the motor armature, and D is the shunt field winding of the motor. E is the motor starter and F the armature of the gene-

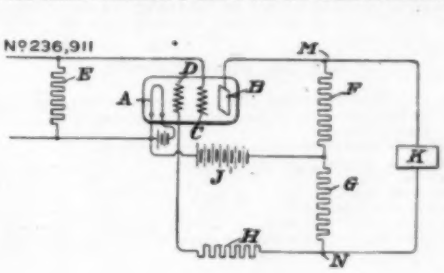


rator mechanically coupled to the motor armature. H is an accumulator to be charged. There are two windings K and L wound on the generator field magnets. The winding K, which corresponds to the series field winding of the generator, is connected in series with the motor armature C and the other winding L, which corresponds with the shunt field winding of the generator, is energised from the supply leads A B, a rheostat M being connected in circuit for regulating purposes. Instead of the winding L being excited from the supply leads A B it may be energised from the generator leads.—*February 11th*, 1926.

TELEGRAPHS AND TELEPHONES.

236,911. June 16th, 1925.—IMPROVEMENTS IN ELECTRON DISCHARGE APPARATUS AND CIRCUIT ARRANGEMENTS THEREFOR, *The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C. 2.*

One of the difficulties encountered in the use of three-electrode amplifiers lies in the fact that there is always a direct current flowing in the plate or output circuit which is much greater than the amplified current. When a uni-directional current is to be amplified it is usually necessary to balance out this initial direct current by some combination of resistance and an auxiliary battery before it is possible to utilise the amplified current. One of the objects of this invention is to overcome this disadvantage inherent in three-electrode valve amplifiers. An arrangement including a four-electrode valve is used in which there will normally be no direct current flowing in the load circuit. The valve has the usual electron emitting cathode A and anode B, a control grid C, and a space charge grid D. There is a resistance E in the control grid or input circuit across which the voltage to be amplified is introduced. An impedance made of two ohmic resistances F and G has one terminal connected

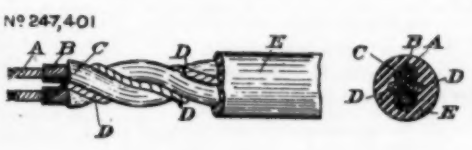


directly to the anode B and its other terminal connected to the space charge grid D through an ohmic resistance H. The cathode A is connected through a battery J to a point between the two parts F and G of the impedance. A load circuit containing any desired form of current indicating or utilising device K is also connected to the terminals of the impedance. In the operation of the system the values of resistances F, G and H are so adjusted that when no voltage is applied across resistance E the currents flowing through F and G are of such value that the voltage drops in the two are equal. Points M and N will then be at the same potential and no current will flow in the load circuit. Ordinarily the space charge grid should be at a lower potential than the anode and the value of resistance H is chosen to bring the potential of the space charge grid D to the proper value. This resistance H, together with resistance G, tends to raise the mutual conductance of the device above what it would be if the space charge grid were connected directly to battery J. When the potential of the control grid is changed by the application of voltage to the input circuit the anode current and the current to the space charge grid vary, but in opposite directions.—*February 18th*, 1926.

TRANSMISSION OF POWER.

247,401. March 3rd, 1925.—IMPROVEMENTS IN ELECTRIC CABLES, Callender's Cable and Construction Company, Ltd., of Anchor Works, Leigh; and Stanley James Bryce, of the same address.

The cable dealt with in this specification is of the type in which the strands of a single twin or multicore cable have associated with them a textile cord or a number of textile threads adapted to take the tension of any pull applied to the completed



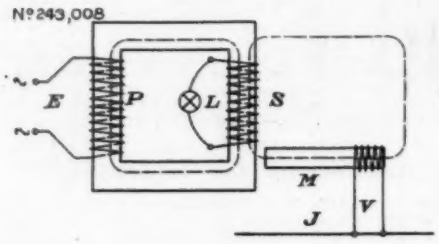
cable. According to the patented arrangement one or more insulated conductors are plaited with one or more textile cords and enclosed within a common sheathing. Each core A comprises a cord of textile fibrous material, preferably a heald cord or alternatively a number of individual textile threads having a number of metallic wires B helically wound around them. Each core is then covered with the usual insulating rubber compound C or other insulating material. Each core thus formed is then

interwound with one or more similar cores. The illustrations show two cores interwound while a number of cords D of textile fibrous material are wound with the cores to act as a reinforcement. It will be noticed that the cords D of the textile fibrous material are commensurate in number with the conductors. The conductors with their reinforcement members D are then covered with textile fibrous material to form an insulated cable or with the usual tough rubber or similiar flexible sheathing E. In this way an electric cable capable of carrying current and at the same time adapted to resist substantial strain without breaking the metallic conductors is formed.—*February* 10th, 1926.

MEASURING AND TESTING INSTRUMENTS.

243,008. November 13th, 1925.—IMPROVEMENTS IN ELECTRIC POWER FACTOR INDICATORS, Heinrich Müller, of Lichtensteinstrasse 69, Vienna, IX, Austria.

As compared with ordinary power factor meters, the instrument described in this specification is claimed to offer the advantage of simplicity of construction and cheapness. It consists of a transformer, the primary winding P of which is energised by the voltage of the network E. To the secondary winding S a lamp L is connected. M is an electro-magnet, the winding of which is placed across a voltage which is obtained from the consumption circuit and the magnitude of which is dependent upon the consumption current in the line J. The magnetic flux of the electro-magnet is closed, as shown by the dotted line through the core member of the transformer which carries the secondary coil. The proportions are so designed that the flux of the electro-magnet when the power factor in the consumption

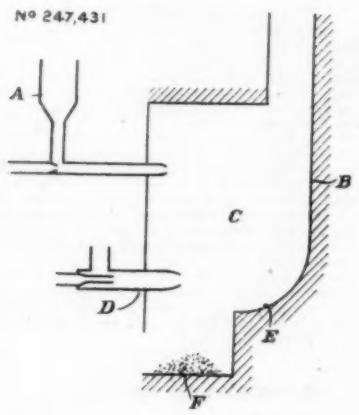


circuit is equal to unity counteracts the flux of the transformer to such an extent that the secondary voltage of the transformer is insufficient to cause the glow lamp to light. The greater the phase displacement in the consumption circuit the more the phase of the voltage at V changes, and with it the phase of the flux of the electro-magnet, in relation to the phase of the transformer flux. Consequently in the transformer iron member carrying the secondary winding there is a continuously increasing resultant flux, which finally generates in the secondary winding a voltage which causes the glow lamp to light. The adjustments are made so that the glow lamp lights up at the minimum permissible value of the power factor. In order that the flux passing from the electro-magnet into the transformer iron may remain constant even when the voltage at V is rising, the electro-magnet iron is always kept saturated and the exciting coil is arranged substantially at the end of the electro-magnet iron remote from the transformer iron.—*February* 18*th*, 1926.

WATER PURIFICATION.

247,431. April 29th, 1925.—MANUFACTURE OF BODIES FOR THE PURIFICATION OF WATER, E. M. G. Fréchou, 5, Avenue Pasteur, Paris.

The inventor claims that his process, described below, provides a very cheap means of manufacturing base-exchange material for the softening of water in the same manner as is the case when artificial zeolite is used. A mixture of ashes and carbonate of soda and fuel, the ashes of which are to be used with the carbonate of soda, after being finely ground or pulverised is delivered from a receptacle or hopper A by compressed air or

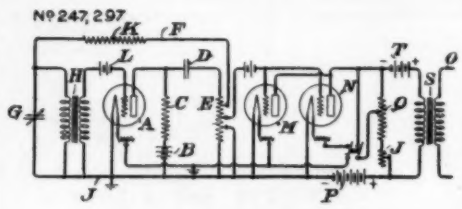


any other means into and against the wall B of the chamber C which has been previously brought to the required temperature (1000 deg. to 1200 deg. Cent.) by gas distributed by the burner blow-pipe D or by any other means. By contact with the hot wall B the ashes and carbonate of soda fuse and flow down the wall into the collecting crucible E and overflow therefrom on to the plate F. During this descent, and also in the crucible E, the required combination is effected, so that a material directly utilisable for the purification of water can be recovered at F.—*February* 18th, 1926.

MISCELLANEOUS.

247,297. November 14th, 1924.—IMPROVEMENTS RELATING TO THE PRODUCTION OF ELECTRIC OSCILLATIONS, *The Western Electric Company, Ltd., of Connaught House, Aldwych, London, W.C. 2.*

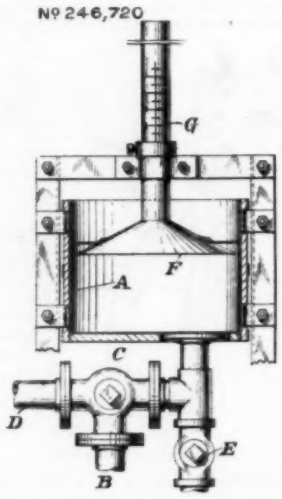
This invention relates particularly to apparatus adapted to produce low-frequency oscillations of very pure wave form. The oscillator comprises one or more valves A with a space current source B connected through a series resistance C. Connected across the plate and cathode is an alternating-current path including a capacity D and a high resistance E, to which a feedback conductor F is connected. A variable capacity G and a primary winding of a transformer H constitute a frequency-determining circuit upon which oscillations are impressed through the common earth conductor J and the feed-back path F, which includes high resistance K. The transformer H is specially designed to transmit low-frequency currents effectivsly and to be very efficient when operated at low core flux density. The resistance K of the feed-back path restricts oscillations fed back to small magnitude. Its variable connection to the resistance E permits the electromotive force impressed on the grid circuit to be regulated as desired. A battery L is used to polarise the grid negatively and the alternating electromotive force induced in the secondary winding of transformer H is maintained so small in magnitude that the grid does not become positive and hence does not tend to draw space current from the cathode. Consequently the oscillations in the grid cathode circuit are symmetrical and substantially free from harmonics. The plate circuit includes in its space current path a resistance C having a valve corresponding to the internal plate circuit alternating-current impedance of the valve itself. The impedance of the alternating-current paths through resistances E and K are of the order of several times the valve internal plate circuit impedance. It follows that the combined tube and external circuit characteristic is fairly linear over a considerable range of grid potential variations. The effect of this is to permit the amplifier to amplify



impressed alternating input waves without substantial distortion. The oscillations in the resistance E set up a potential difference in the input circuit of an amplifying system comprising one or more amplifiers M permanently connected in circuit and one or more additional amplifiers N adapted to be connected in parallel as circumstances dictate. The output circuit of these amplifiers is associated with a load circuit O by means of a magnetic core transmitter S designed to transmit efficiently alternating current at low frequencies. It is desirable to prevent direct-current polarisation of the primary winding and to do this without interposition of a blocking capacity. For this purpose the space current of the amplifier M supplied by a battery P is caused to traverse a resistance Q. The primary winding of transformer S is in a shunt path with the resistance Q, the path also including a neutralising source of voltage T. Any tendency for space current to flow through the primary winding is overcome by the opposite voltage source T, the variable resistance enabling an exact balance to be obtained. The circuit is claimed to permit low-frequency currents to be transmitted very effectively, and by reason of leakage inductances of the transformer, causes some discrimination in favour of low-frequency currents as against those of higher frequencies.—*February* 15*th*, 1926.

246,720. June 22nd, 1925.—MEASURING BITUMEN CHARGES, J. M. T. Johnston, 79, Mark-lane, London, E.C. 3, and A. D. Collins, Glenwood, Farnham-road, Guildford, Surrey.

In the preamble to this specification it is pointed out that the generality of appliances for measuring out such materials as melted bitumen for road-making jobs have several disadvantages, and this apparatus is intended to meet such difficulties. It comprises a measuring vessel A, which is supplied with



melted bitumen through the branch B and three-way cock C, which has a return way D, so that the bitumen may be kept in circulation when it is not required in the measuring device. The cock E provides an outlet for the measured bitumen. The actual measurement is effected by means of the conical-shaped float F, which is provided with a funnel G, that takes away any fumes, and incidentally is graduated to show the content of the measuring chamber.—*February 4th*, 1926.

PENSIONS IN THE METAL TRADE.—A special effort is being made by the Royal Metal Trades' Pension and Benevolent Society to increase its funds by such an amount, estimated at £10,000 a year, as would enable it to increase pensions substantially. The Lord Mayor is issuing an appeal to the metal industry, and we understand that his Royal Highness the Prince of Wales has consented to attend a festival which is to be held at Guildhall on June 1st.

A JUBILEE OF SERVICE.—Mr. F. H. Livens, M.I. Mech. E., director and chief engineer of Ruston and Hornsby, Ltd., completed fifty years' service with that company last month, and, in recognition of the fact, at a board meeting held on March 23rd, the chairman, on behalf of the company and directors, presented him with an oil painting as a mark of their personal friendship and esteem, and of their great appreciation of his valued services. The hope was also expressed that they would have the benefit of his experience for many years to come. The picture is by Miemann, and the subject "Lincoln," as seen in 1858 from the Witham banks of the south-east of the city. It was formerly in the collection of Mr. Alfred Shuttleworth.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TUESDAY, APRIL 6TH.

INSTITUTE OF METALS: BIRMINGHAM LOCAL SECTION.—Chamber of Commerce, New-street, Birmingham. Annual general meeting. 7 p.m.

WEDNESDAY, APRIL 7TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Cavendish Café, Cornmarket, Derby. Derby Graduates' meeting. Paper, "Problems of the High-speed Optical Indicator," by Mr. A. A. Rubbra. 7.30 p.m.

THURSDAY, APRIL 8TH.

INSTITUTE OF METALS: LONDON LOCAL SECTION.—Institute of Marine Engineers, 85–88, The Minories, Tower Hill, London, E. 1. Discussion on "Production of Sound Castings," opened by Mr. R. Genders. 7.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS.—Savoy-place, Victoria Embankment, London, W.C. 2. "The Applications of Machinery at the Coal Face," by Mr. S. Mavor; "The Design of Storage Battery Locomotives for Use in Coal Mines," by Mr. L. Miller; "Electricity in Mines: A Short Survey," by Mr. R. Nelson. 6 p.m.

ROYAL AERONAUTICAL SOCIETY.—Royal Society of Arts, 18, John-street, Adelphi, London, W.C. 2. Paper, "A 35,000 Miles' Flight," by Marchesse De Pinedo. 6.30 p.m.

FRIDAY, APRIL 9TH.

DIESEL ENGINE USERS' ASSOCIATION.—Caxton Hall, Westminster, London, S.W. 1. Paper, "Industrial Tests on Internal Combustion Engines," by Mr. W. A. Tookey. 3.30 p.m.

INSTITUTE OF MARINE ENGINEERS.—85–88, The Minories, Tower Hill, London, E. 1. Annual meeting. 6.30 p.m.

INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—Applied Science Department of the University, St. George's-square, Sheffield. Joint meeting with the Sheffield Silver Trades Technical Society. Paper, "Silver from Mine to Market," by Mr. E. A. Smith. 7.30 p.m.

INSTITUTION OF CIVIL ENGINEERS: BIRMINGHAM AND DISTRICT ASSOCIATION.—Chamber of Commerce, New-street, Birmingham. Paper, "Water Supply from Underground Sources," by Mr. J. E. Dumbleton. 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, London, S.W. 1. Paper, "Modern Methods of Cast Iron Pipe Manufacture," by Mr. T. E. Dimbleby. 7.30 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Literary and Philosophical Society's Lecture Theatre, Newcastle-upon-Tyne. Paper, "Hydro-mechanical Marine Gearing," by Mr. James Richardson. 7.30 p.m.

RAILWAY CLUB.—65, Belgrave-road, London, S.W. 1. Paper, "Signals and Signalling," by Mr. C. N. Anderson. 7.30 p.m.

SATURDAY, APRIL 10TH.

JUNIOR INSTITUTION OF ENGINEERS.—Visit to the works of the South Metropolitan Gas Company, East Greenwich. 2 p.m.

MONDAY, APRIL 12TH.

INSTITUTION OF STRUCTURAL ENGINEERS.—Piccadilly Hotel, London, W. 1. Annual dinner. 7 for 7.30 p.m.

TUESDAY, APRIL 13TH.

INSTITUTE OF MARINE ENGINEERS.—85-88, The Minories, Tower Hill, London, E. 1. "Double-acting Oil Engines," by Mr. W. S. Burn. 6.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—39, Elmbank-crescent, Glasgow. Paper, "Dunlop Tyres and their Uses," by Mr. A. Healey. 7.30 p.m.

WEDNESDAY, APRIL 14TH.

CHEMICAL ENGINEERING GROUP.—Burlington House, Piccadilly, London, W. 1. Joint meeting with the Institution of Chemical Engineers. Paper, "The Beet Sugar Industry," by Mr. J. Kwantes. 8 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS.—Savoy-place, Victoria Embankment, London, W.C. 2. Wireless Section meeting. "The Rugby Radio Station of the British Post Office," by Mr. E. H. Shaughnessy. 6 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS: SOUTH MIDLAND CENTRE.—The University, Edmund-street, Birmingham. Discussion on "The Government Electricity Bill." 7 p.m.

LIVERPOOL ENGINEERING SOCIETY.—9, The Temple, Dale-street, Liverpool. Paper, "The Properties and Engineering Uses of Stainless Steel," by Mr. R. Waddell. 8 p.m.

THURSDAY, APRIL 15TH.

INSTITUTION OF CIVIL ENGINEERS: BIRMINGHAM AND DISTRICT ASSOCIATION.—Visit to Coombs Wood Collieries and Netherton Ironworks of N. Hingley and Sons, Ltd.

FRIDAY, APRIL 16TH.

INSTITUTION OF MECHANICAL ENGINEERS.—Storey's-gate, Westminster, London, S.W. 1. Paper, "Modern Development of Paper Mill Plant," by Messrs. W. Worby Beaumont and L. N. Burt. 6 p.m.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Town Hall, Manchester Old-road, Middleton. North-Western District meeting. 11 a.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, London, S.W. 1. Lecturette, "Automobile Lighting, Starting, and Ignition," by Mr. T. L. Allison. 7.30 p.m.

TUESDAY, APRIL 20TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. Paper, "Experiments on Laminated Springs," by Mr. H. S. Rowell. 7.30 p.m.

WEDNESDAY, APRIL 21ST.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Town Hall, Melksham, Wilts. Southern District meeting. 11 a.m.

THURSDAY, APRIL 22ND.

INSTITUTION OF ELECTRICAL ENGINEERS.—Savoy-place, Victoria Embankment, London, W.C. 2. Seventeenth Kelvin Lecture, "The Mechanics of the Electric Field," by Sir J. J. Thomson. 6 p.m.

FRIDAY, APRIL 23RD.

INSTITUTE OF METALS: SWANSEA LOCAL SECTION.—Metallurgical Department, University College, Singleton Park, Swansea. Annual general meeting. 7.15 p.m.